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AUTHOR Case, Christine L.
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ABSTRACT

This study was undertaken to determine the effects of individualized instruction on enrollment, attrition, achievement, and student attitude in a general biology course for non-science majors. Fifteen auto-tutorial minicourses were designed for use in the laboratory part of the course, each consisting of a printed study guide, slide-tape module, laboratory exercise, grade-option activity, objective post-test, and evaluation. Data from the classes receiving conventional instruction during the spring of 1977 were compared to data gathered during the fall semester using auto-tutorial instruction. Results showed that enrollment and student retention were improved using auto-tutorial instruction. Final grades received by the experimental group were significantly higher than those achieved by students in conventional classes. A direct correlation was shown between time spent in the laboratory and final grades. Students' attitudes were positive about auto-tutorial instruction and the minicourses, which were found to be of generally good quality, contributed to the learning of the students. Although no preference for either type instruction was shown by the auto-tutorial students, the students in conventional classes favored that type of instruction. (VT)

THE DEVELOPMENT, IMPLEMENTATION AND EVALUATION OF INDIVIDUALIZED INSTRUCTION IN LABORATORY FOR MAN IN A BIOLOGICAL WORLD AT SKYLINE COLLEGE

CHRISTINE L. CASE

A MAJOR APPLIED RESEARCH PROJECT
PRESENTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR
THE DEGREE OF DOCTOR OF EDUCATION

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Abstract of a Major Applied Research Project Presented to Nova University in Partial Fulfillment of the Requirements for the Degree of Doctor of Education

THE DEVELOPMENT, IMPLEMENTATION AND EVALUATION OF INDIVIDUALIZED INSTRUCTION IN LABORATORY FOR MAN IN A BIOLOGICAL WORLD AT SKYLINE COLLEGE

by

Christine L. Case

May, 1978

"Man in a Biological World" is the only laboratory life science course with which students can fulfill General Education requirements at Skyline College. "Man in a Biological World" was taught in a traditional format with three lecture hours and three laboratory hours each week, and enrollment and retention in the course were low for the five semesters during which it was offered.

The purpose of this study was to develop and use auto-tutorial instruction for the laboratory portion of "Man in a Biological World" for the Fall 1977 semester. Students were able to work in the laboratory as much as they required in order to complete each week's laboratory assignment.

Fifteen minicourses were produced, each included a printed study guide, slide-tape module, laboratory exercise, grade option activity, post-test and evaluation. The amount of time each student spent in the laboratory

was recorded. Final grades were determined on the basis of study guide and post-test scores and three examinations.

Student enrollment, attrition and final grades for previous semesters were obtained from the Registrar's Office.

Hypotheses were formulated with regard to comparing auto-tutorial and conventional instruction. Statistical analyses were performed and 5 percent was accepted probability.

It was assumed that the student groups compared in this study were the same and that neither group was familiar with both methods of instruction. One limitation accepted was that only the laboratory portion of the course was modified for individualized instruction. Students attended three traditional lecture/discussion hours each week in addition to the self-paced laboratory.

A final course evaluation was administered to the Spring 1977 conventional students and the Fall 1977 auto-tutorial students to determine students' attitudes and opinions about the methods of instruction.

Minicourse evaluations were completed each week by auto-tutorial students. Sixty-seven percent of the students giving similar responses was accepted as significant.

The results of this study showed that enrollment and retention were improved using auto-tutorial instruction.

Enrollment in the auto-tutorial course was 72 percent of the expected enrollment compared to 44 percent in the conventional course. The attrition rate in the conventional course was 27 percent; in the auto-tutorial course the attrition rate was 5 percent. Final grades received by auto-tutorial students were significantly higher than those achieved by conventional students. A direct correlation was shown between time spent in the laboratory and final grades. Students earning grades of A and B spent more than three hours per week in the laboratory.

Students' attitudes were positive about auto-tutorial instruction. Auto-tutorial students rated laboratory exercises more stimulating and relevant than did conventional students. The laboratory exercises were the same for both groups of students, only the presentations differed. No correlation was shown between student scores on the minicourses and minicourses that were rated high or low.

The students listed the laboratory exercises in order of their preference. Outdoor field trips were ranked highest by both groups of students. Field trips should remain an integral part of this course.

Hypotheses were formulated regarding the quality of the minicourses and were assessed using the student evaluations. The minicourses were found to be of generally good quality and contributed to the learning of the students.

No preference for auto-tutorial or conventional instruction was shown by the auto-tutorial students. The conventional students favored conventional instruction.

Auto-tutorial instruction was successful in the laboratory portion of "Man in a Biological World." Auto-tutorial instruction will provide consistant laboratory instruction. The students will have freedom in scheduling their classes and will be able to work in the laboratory when they are able.

Student success in the auto-tutorial course can be attributed to:

1. Students feeling they could succeed because they were given sufficient time and opportunity.

2. Students liking being responsible for their own learning.

3. Students finding minicourses interesting and a stimulus to continue in the course.

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INTRODUCTION

Background and Significance

Students at Skyline College must complete six semester units of science to fulfill the General Education requirements for the Associate of Arts Degree at Skyline College. The science courses may be any combination of life and physical sciences. Students preparing to transfer to some four-year colleges and universities must take a science course with a laboratory. The only non-biology major laboratory course presently offered at Skyline College is "Man in a Biological World."

Since the opening of Skyline College in 1969, enrollment in biology courses has been low. The biology faculty has been changing biology courses to include relevant and more interesting subject material. In 1974 the biology faculty decided that General Biology (laboratory course) and Life Science (lecture only) were not meeting the needs of non-science majors because the contents of these courses were simplified versions of those designed for biology majors. The need was to develop a course specifically designed for students who did not plan to pursue careers in biological science. For example, the non-biology majors may not need to memorize a list of

facts. Instead these students need to be provided with the necessary tools with which to interpret genetic regulation, nutrition needs and population growth (Dodge, 1976). Thus General Biology was deleted from the curriculum. The course outline for Life Science was suitable. The biology faculty saw a laboratory requirement as necessary to provide experiences and an investigative approach that would facilitate learning. Faculty members each wrote one to five laboratory exercises that hopefully would be stimulating for the students and provide the type of course needed by non-biology majors. The new laboratory course, "Man in a Biological World," resulted.

"Man in a Biological World" had been taught in a traditional format with three lecture hours and three laboratory hours each week from Spring 1975 through Spring 1977. Each laboratory period began with a 50- to 90-minute introductory lecture. Two or more sections of "Man in a Biological World" were offered each year. Since its adoption, "Man in a Biological World" has been taught by four instructors. The laboratory exercises used in each section were the same. However, the introductory lecture for each laboratory period was highly variable depending on the instructor. It was intended that the course content should be the same for all students and testing and grading be constant for the course.

Brewer (1974) lists the following disadvantages of this conventional approach:

1. The quality of material varies with the instructor.

2. The instructor gives the same material with lessening enthusiasm.

3. The student needs his/her own labelled demonstration material.

"Man in a Biological World" was offered five semesters (Spring 1975 through Spring 1977). The average enrollment in this course was approximately 40 percent of the projected enrollment. Further, an average of 27 percent of the students enrolled each semester withdrew from the course and an additional 15 percent received grades of D or F.

The general goals of a biology course for non-science majors should be to increase students' science literacy and improve their ability to decide the future of mankind in its struggle with overpopulation, use of resources and preservation of the environment (Walker, 1972). The biology faculty at Skyline College believe that "Man in a Biological World" was such a course. But the course had not been reaching a broad spectrum of the students. It is hypothesized that 90 percent of the students can achieve mastery (Bloom, 1973). However there are differences in students and instructional methods

should take these differences into account to promote maximum learning for each student. Carroll (1963) defines aptitude as the amount of time required to master a given amount of material. The instructional format should include varying the amount of time that each student can spend so that each student can achieve mastery.

The purpose of this study was to develop auto-tutorial minicourses for use in the laboratory portion of "Man in a Biological World." It was intended that these minicourses would provide a "consistancy" for each section of the course and the effects of instructor variability would be reduced as a factor in attrition in the course. The students were able to use the minicourses and complete each laboratory exercise at their own pace. Using conventional instruction, the entire class had to be in the laboratory for an assigned three-hour block of time each week.

The minicourses produced were used for the laboratory instruction in the Fall 1977 semester. Students received individualized instruction in the laboratory portion of this course. The laboratory was open for their use 18 hours during the week. The students attended a one hour lecture-discussion period three times each week.

Research Questions

The low enrollment in "Man in a Biological World" from Spring 1975 through Spring 1977 was a problem. A maximum class size was established and an average of 40 percent of each class was filled. Biological education is critical in a technological society and Skyline College was not reaching its students with this vital program. Low enrollment could be due to a number of factors:

1. Students preferred lecture-only courses.
2. This course did not have a reputation as an "interesting course."
3. Student success in this course had been poor.

Student attrition in "Man in a Biological World" was high. In the past five semesters an average of 27 percent of the students withdrew each semester by the ninth week of instruction. These students were not succeeding in a course described in the Skyline College catalogue as having no prerequisites and designed as a General Education course.

In this study an alternative method of instruction was used for the laboratory portion of "Man in a Biological World" to determine whether more students could be reached and with better student performance.

Hypotheses

"Man in a Biological World" was offered during the Fall 1977 semester with three lecture-discussion

hours per week and laboratory "By Arrangement." Students were able to work on laboratory experiments whenever the laboratory was open. The effectiveness of individualized instruction in "Man in a Biological World" was evaluated by the following null hypotheses.

Hypothesis #1: Individualized instruction has no effect on initial enrollment in "Man in a Biological World."

Initial enrollment figures were used to address the first hypothesis. The students did not have to sign-up for a three hour laboratory. The laboratory was listed in the Class Schedule as "By Arrangement" for the Fall semester. Chi Square was used to ascertain whether the freedom in scheduling afforded by individualized instruction has a significant effect on enrollment.

Hypothesis #2: Individualized instruction has no effect on the attrition rate in "Man in a Biological World."

Students can withdraw from classes up to the ninth week of instruction without a penalty. After this time, the instructor can assign a final letter grade. The number of students enrolled in a course at the ninth week of instruction is reported to the College Registrar. These data are kept in the Registrar's permanent files. Two-sample test of population proportions was used to compare the attrition rate at the ninth week of the Fall semester with that of previous semesters to determine if individualized instruction had a significant effect on the attrition rate.

Hypothesis #3: Individualized instruction has no effect on student achievement in "Man in a Biological World."

Final grades given in each class are recorded in the Registrar's Office. Chi Square was used to compare the final grades of students using individualized instruction with the final grades of students during previous semesters to determine the effects of individualized instruction on student achievement.

Hypothesis #4: Students in "Man in a Biological World" are indifferent toward individualized instruction.

A final course evaluation was completed to ascertain students' attitudes toward individualized instruction. The evaluation form is included in Appendix II. Students enrolled in "Man in a Biological World" during the Spring 1977 semester completed this evaluation. Their responses were compared with the responses of students receiving individualized instruction during the Fall 1977 semester.

Hypothesis #5: Individualized instruction does not affect the length of time students spend in the laboratory.

Students signed into and out of the laboratory on time cards. The average number of hours spent in the laboratory each week per student was recorded. During previous semesters (Spring 1975 through Spring 1977) students could remain in the laboratory only during the

scheduled three hour laboratory period. The amount of student laboratory time during the Fall semester was compared to three hours per week during previous semesters to determine whether individualized instruction affected the length of time spent in the laboratory.

Hypothesis #6: Final grades are not proportional to the length of time spent in the laboratory.

The Spearman-Rank order correlation was used to determine whether the time spent in the laboratory is proportional to final grades in "Man in a Biological World."

The minicourses produced during this project were evaluated by students during the Fall semester. The evaluation form is included in Appendix I. The student responses were summarized and used to make a qualitative evaluation of the effectiveness of the minicourses with regard to null hypotheses 7 through 11.

Hypothesis #7: The stated objectives were not achieved. Questions one through three of the minicourse evaluation were used to make this determination.

Hypothesis #8: The audio presentation was not clear and easy to follow. Questions four through eight on the minicourse evaluation were used to make this determination.

Hypothesis #9: The study guides were not effective. Questions nine through eleven on the minicourse evaluation were used to make this determination.

Hypothesis #10: The visuals were not effective in contributing to learning the material presented. Questions twelve through fourteen on the minicourse evaluation were used to make this determination.

Hypothesis #11: The laboratory exercises were neither stimulating nor relevant. Questions fifteen and seventeen on the minicourse evaluation were used to make this determination.

Definition of Terms

Expected enrollment: A limit on the number of students who can enroll in a class is determined prior to student registration. This limit is based on the number of desks in a classroom.

Laboratory course: A laboratory course has two or three hours of lecture and one three-hour laboratory period each week for 15 weeks. This laboratory period is scheduled for one three-hour block of time. The format is a 30-minute lecture followed by the students doing an experiment.

Lecture-only course: A lecture-only course is three one-hour lectures each week or two 90-minute lectures weekly for 15 weeks.

Letter grade: Grades of A, B, C, D and F are assigned at Skyline College. Credit/No Credit or Pass/Fail options are not available to the students in biology courses.

Minicourse: One instructional laboratory unit. Instruction method may include computer-assisted instruction, programmed workbook, slide-tape module, etc. (BSCS, 1974).

Module: A series 35-mm color transparancies with a synchronized tape recorded lecture.

Section: A course may be offered more than once in a semester. Each scheduling of this course is called a section.

Study guide: Printed material used by the student. Can be assigned independently or can accompany a module or other instruction method. The study guide includes objectives, background information, procedures, and study questions.

W grade: A student may withdraw from a class without a penalty grade at any time up to the ninth week of instruction. After this time the instructor may assign a letter grade as appropriate.

Assumptions and Limitations

This study has applicability to the Life Science Division at Skyline College. Only the laboratory portion of "Man in a Biological World" was evaluated. Modifications therefore were based on evaluation of the laboratory. The limitations of this study also included the differences in instructor methodology. Sections were not taught by

the same instructor and enrollment reflected the individual instructor's policies and presentations. The material presented in each section was different depending upon the instructor. The instructor for the Fall 1977 section of "Man in a Biological World" did not teach this course during the previous semesters (Spring 1975 through Spring 1977).

The study sample was an uncontrolled variable. Students were assisted in their selection of courses by counselors, but the sampling of students in general education courses was not subject to controls.

It was assumed for this study that the student groups in each class represented the same distribution span in terms of their background in science courses, experience in college and grade point averages.

It was also assumed that the conventional method of instruction was the reason for poor student achievement in "Man in a Biological World."

Because students were assisted in their scheduling of classes by counselors, there may have been some bias in the programming depending on the counselors' choice of instructors. This may have influenced initial enrollment because the instructor during the semester under study had not taught the course previously. It was assumed however that the instructor had no effect on retention during the Fall semester.

REVIEW OF LITERATURE

> The right to learn is the goal we seek in the twenty-first century. We want for our children a range of learning opportunities as broad as the unknown range of their talents. We want a learning environment that nurtures those talents.
>
> Goodlad, 1973

The primary goal of community colleges is to teach, and therefore the most effective instructors and teaching methods must be provided (Boyer, 1973). However, "faculty members . . . sometimes are not prepared to teach in accordance with the unique philosophy of [the community college]. They may be academically inclined subject-matter specialists who think in terms of their own graduate-school experience" (Roueche, 1973). This can often be the case in the sciences. Conventional biology courses tend to serve biologists.

Dodge (1976) states that biological education has not kept pace with career training or the public's need to understand biological principles. "As society becomes increasingly aware of the influences of biological knowledge on population control, disease, food production, environmental protection, and genetic regulation" non-biologists will be involved in making decisions requiring biological information (Dodge, 1976).

The President's Commission on Population Growth (1972) has stated that the vast majority of the people need education to develop an understanding of population growth and distribution. Kelley (1972) points out that education "must provide the knowledge that will help individuals to understand the physical world in which man lives . . . . Experiences should be provided to acquaint the learner with the natural resources of the world. . . ."

Science is not just to train professionals. Dodge (1976) refers to the social worker who needs a knowledge of nutrition and the lawyer who needs to know medical terminology as "parabiologists." And Bevan (1972) states that people need to know more of the pleasure of observing the phenomena of nature.

In classes for non-biology majors emphasis should be placed on the students' ability to solve problems through inquiry and induction. Instead the conventional approach has been "to cram more and more facts into lecture" (Kortiz and Calley, 1974). Material that is pertinent to the daily lives of these students should be included in lectures, not molecular formulae and life cycles. For example, Degnan (1976) points out that Mendelian genetics should be taught using sickle cell anemia rather than sweet peas.

Gillis (1972) had success in a computer science class when he began teaching how and why computers were

used instead of attempting to train each student to become a computer technician. At Yale University classical biology for non-science majors was replaced with a social science-science course (Galston, 1972). This lecture-only course was an attempt to teach subject matter that would have meaning to all citizens. Galston (1972) is not confident about the success of the course because of what he sees as the inabilities of science teachers to deal with social, political and economic implications.

Community colleges differ from the traditional concept of college in that "everyone" can go to a community college (Roueche, 1973). In this regard the students are different from traditional college students. In support of this difference, Trent and Medsker (1967) reported that 98 percent of first-time students did not complete a second year of college. Because the students are different the traditional teaching methods are not always the best (Gillis, 1972).

Bloom (1973) states ". . . 90 percent [of the] students can learn what we have to teach them [and] our task is to find strategies that will take individual differences into consideration but will do so in a way as to promote the fullest development of the individual." At present there is no agreement as to the type of instruction that is best. Mager (1968) defines teaching as causing a student to use something and simultaneously

create a desire in the student to learn more. To accomplish this the instructor must involve the student (White, 1977). Learning is an individual phenomenon resulting from strategically planned teaching methods (Roueche and Herrscher, 1970). New information should be presented sequentially since new capabilities are based on previously learned capabilities (Gagne, 1970).

Traditionally "all students are . . . locked into step with set schedules . . . [and] established sequences and constraints" (Kormondy, 1971). Yet repeated research shows that learning is individual, and geneticists point out that one human being is distinctly different from another (Hardin, 1964). Conventional instruction often does not involve the student nor does it acknowledge differences among students. Conventional instruction usually relies on teaching concepts or "rule and examples" and not on utilization or "discovery" (Gagne and Brown, 1961). In 1916 Dewey stated that "teaching should bring about experiences." Thus it is that the "hands-on" concept in biology laboratory courses can offer a practical learning experience. It is the opinion of the author that the subject material presented in laboratory courses needs to be varied from the traditional dissections and observations of prepared slides. An investigative laboratory develops students' concerns for real issues. Edson (1972) states

that laboratory courses must break from the traditional sequence of "cookbook" experiments.

Meleca (1973) reports that the auto-tutorial approach is a viable way to teach biology to non-science majors. He stated that biology instructors see these students as "other people's kids." In this study, students using auto-tutorial instruction in a genetics sequence of General Biology scored significantly better than a control group using conventional instruction. In Animal Biology, auto-tutorial students scored better than conventional students on immediate post-tests and a retention test administered 11 weeks after completion of the course (Rowsey and Mason, 1975). Students receiving individualized instruction achieve better in problem solving then conventional students (Everest, 1975). Sturges and Grobe (1976) and Quick (1971) reported that students receiving auto-tutorial instruction and students receiving conventional instruction showed no difference in achievement. However, auto-tutorial instruction was cited by Sturges and Grobe (1976) as having distinct advantages over conventional instruction.

> Audio-tutorial instruction provides a means by which students can progress at their own level of ability and motivation. It makes more efficient use of instructional and material resources and provides the instructor with more specific information about individual students.

Auto-tutorial instruction makes the instructor a facilitator of learning rather than a disseminator of information (Glazer, 1974).

Students come to General Biology classes with different cognitive skills and learning styles. Husband's (1972) approach to these students was to use 54 mini-courses from which students could choose their individual sequences. A similar approach at Purdue University resulted in the auto-tutorial students performing the same as conventional students but "with more convenience" (Hechinger, 1970). Arnwine and Juby (1969) report higher grades for students in an experimental auto-tutorial General Biology course than a control group.

Brewer (1974) used the auto-tutorial approach in Plant Anatomy and students were "virtually unanimous that this particular audio-visual course provides a superior atmosphere for effective learning."

The course, "Man in a Biosphere," at Mt. Wachusett Community College (Gardner, Massachusetts) has been taught through auto-tutorial instruction. After five years of using this approach the cumulative student evaluation shows 95 percent of the students preferring the auto-tutorial method to scheduled lectures. Ninety-three percent of the students agreed that the two discussion hours each week in addition to the auto-tutorial assignments were valuable (Ballou and Filteau, 1971).

O'Conner and Peck (1977) suggest a need to offer alternate learning resources for the many different students attending community colleges.

The auto-tutorial method has the following advantages over conventional instruction for the students (Craeger and Murray, 1971).

1. Students are more involved in their own learning.

2. The individual is in control of his/her own rate of progress.

3. The student does not have to cover material with which s/he is already familiar.

4. The student is responsible for his/her own learning.

5. A student may enroll in part of a course and study those auto-tutorial modules that are applicable to his/her goals.

A common misconception is that auto-tutorial instruction is a "lonely learning" experience (House, 1977). Lowars (1970) and Sparks (1971) claim that this is not true because the major professor's voice as recorded establishes a one-to-one situation, and the student is an active participant in his/her learning. It is also important to mention that the machines are under the student's control and are used at the student's convenience. Richason (1970) reports that two-thirds of his

students did not report a loss of personal contact. Wenrich (1971) at the College of San Mateo showed that personal contact received by students in individualized instruction improved the students' attitudes and retention in college. The technology provides an "infinitely patient instructor and a non-competitive environment where the only object is to learn, no matter how long it takes" (Douglas, 1976). Furthermore he contends that the students who succeed develop self-discipline (May, 1977).

Craeger and Murray (1971) list the following advantages of the auto-tutorial method for the instructors.

1. The instructor can organize sequences of experiences.

2. The instructor can focus on a student's deficiencies. In a modular Microbiology course at Antelope Valley College (Lancastor, California) extra teacher time is spent on basic laboratory techniques for students who are underprepared (Footlick, 1976).

3. Assessments of student progress are more easily made.

4. The routine aspects of instruction are minimized.

5. Auto-tutorial modules can be produced by different instructors within the department thus taking advantage of their expertise.

Even in studies where no differences in achievement between auto-tutorial and conventional instruction were evidenced a positive change in student attitude resulting from auto-tutorial instruction was reported (Himes, 1971 and Gunter, 1973).

Keller (1968) introduced a personalized system of instruction with the following statement.

> This is a course through which you may move, from start to finish, at your own pace. You will not be held back by other students or forced to go ahead until you are ready. At best, you may meet all the course requirements in less time than one semester; at worst, you may not complete the job within that time. How fast is up to you. . . .

In a conventional course the student cannot retrieve information disseminated while s/he was not paying attention (Postlethwait, Novak and Murray, 1972). Adcock and Mangan (1970) state that student inattention is conscious and proportional to the lack of stimulation. They report that visual and tactile stimuli encourage attention. These stimuli are not provided in lecture. Audio is the major stimulus in lecture and is the least desirable as shown by Nasser and McEwen (1976). Audio plus print stimuli result in the best student recall (Nasser and McEwen, 1976). Hartman (1961) has demonstrated that combined media increase the student's ability to discriminate among the information provided.

It has been demonstrated that the first ten minutes of a lecture are the most important (Trohanis, 1975). Burns[1] has shown that student recall is best for facts presented during the first 10-minute period and recall falls off proportionally after the initial 10 minutes. This then suggests that short instructional units would facilitate student learning better than 50-minute lectures.

According to Hilgard and Bower (1966) auto-tutorial instruction should include the following elements of cognitive theory.

1. Structure exercises so that the students seek information to solve a problem.

2. Sequence laboratory activities to take small whole units and build to more complex units.

3. Objectives of the learning units that are concepts and not lists of facts.

4. Immediate testing and grading to inform the students of their progress.

5. Statement of goals regarding mastery of the material. Have optional A and B grade assignments available.

6. Discussion groups to facilitate student-teacher interaction. Divergent thinking and innovative ideas may result from the discussions.

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[1]Statement made by R. Burns, Professor of Botany, in a lecture ("Attention, Media, and Multi-Image Presentations") presented at Stanford University, March 11, 1977.

Cross (1976) cites the auto-tutorial method as a way of achieving mastery. Six criteria essential for good learning are met by the auto-tutorial approach (Postlethwait, Novak and Murray, 1972).

1. The student can regulate the amount of repetition to suit his/her needs.

2. The student can study at times when s/he can concentrate fully on the subject.

3. The learning activities can be planned sequentially so that the student has mastered the appropriate background information.

4. The size of the learning unit can be adjusted by the student. Auto-tutorial systems permit moderate self-pacing and students can adjust the number of units studied in a time period.

5. Auto-tutorial systems employ many forms of communication: audio-visual, printed and hands-on.

6. Auto-tutorial systems provide an integrated approach involving various activities that result in a synergistic effect.

Postlethwait in 1973 (Postlethwait and Russel, 1973) stated that auto-tutorial instruction allows each student to proceed at his/her own rate; to skip any portion as long as s/he can demonstrate mastery of the objectives and to repeat portions as often as necessary. However, Postlethwait has recently modified this statement. Based

on more recent work he does not support students proceeding entirely at their own rate. An assignment is available for a set period of time (usually one week). The student can work on the assignment as much as necessary for mastery during that week.[2]

Learning occurs through three basic modes: discipline, problem and experience (Milton, 1972). The students perform or experience some activity to solve the problem. The problem is to master the course objectives. Milton defines the discipline as enrolling in a course. Discipline can also be defined in terms of student motivation and perseverance. Many instructors reserve a percentage of their grading standards to assess student participation, laboratory technique and attendance. Subjective grading policies are difficult to justify to the student and often are "unfair." A student's interest, motivation and perseverance can be quantitatively assessed if the student spends five hours on a 50 minute auto-tutorial lesson. Brewer (1974) states that students do spend five to seven hours on a 50 minute tape, frequently stopping the tape to carry out a related practical observation. In an auto-tutorial geography course, Richason (1970) showed that the amount of time spent on the auto-tutorial lessons was proportional to the grade achieved by the student.

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[2]Statement by S. N. Postlethwait, Professor of Botany, in Chautauqua Course, Stanford University, March 11, 1977.

Students earning a grade of A spent 46 percent more time than students receiving an F. Wallach (1976) states that instructors should not rely on test scores of students but on professional competencies. Professional competencies are rated subjectively in a traditional instructional format. Auto-tutorial methods provide objective criteria for evaluating student performance and motivation.

PROCEDURES AND METHODOLOGIES

"Man in a Biological World" was scheduled with three lecture hours and laboratory "By Arrangement" during the Fall 1977 semester. The laboratory was open for student use 18 hours each week. The students completed one minicourse each week. Each student spent the amount of time personally required to complete each minicourse. Students attended three one-hour lecture/discussion periods each week. The lecture/discussion was in a conventional format. An effort was made to coordinate the lecture with the current laboratory assignment.

Development of the Minicourses

The minicourses were prepared following an outline by Murray (1971). Murray suggests that each minicourse consist of (1) statement of purpose, (2) instructional objectives, (3) necessary materials, (4) sequential steps, (5) related experiences, (6) evaluative post-test and (7) assessment of the minicourse. The format for each minicourse developed for "Man in a Biological World" was

1. A four to 20 page printed study guide.

2. A slide-tape module consisting of approximately 65 color transparencies and a 30 minute cassette tape.

3. Laboratory experiments performed by the students.

4. A Grade Option Activity (GOA) to be completed by students working for a grade of A or B. The GOA was a related experiment designed to provide the student with more advanced conceptual material.

5. A 15 point objective post-test.

6. A minicourse evaluation (see Appendix I).

Laboratory handouts for 15 topics covered in "Man in a Biological World" laboratory were available. These were the handouts previously used in this course (Spring 1975 through Spring 1977). The laboratory experiments were evaluated by students at the end of the Spring 1977 semester (see Appendix II). The responses to the evaluation are included in Appendix II-A. Table 1 shows the responses to two of the questions on the course evaluation. The responses indicated that some of the laboratory exercises did not have sufficient activities. Each laboratory exercise was performed by student assistants on a trial basis. Related exercises were consolidated in a single minicourse. This left 13 laboratory exercises for a sixteen week course. Three minicourses were developed de novo. A list of the minicourses is included in Appendix III.

Table 1. Student responses to questions #6 and #10 on the course evaluation (Spring 1977). Data expressed in percentages.

Question #6:			
Amount of work required in lab:			
A--too little	A	B	C
B--appropriate	35	60	5
C--too much			
Question #10:			
	Agree	Neither	Disagree
Labs. relevant to my interests	42	24	10

A script and storyboard were prepared for each minicourse. Color transparancies were taken to illustrate the material covered in the laboratory exercise. Each module included approximately 65 35-mm color transparancies. The audio portion of the module was recorded on cassette tape and electronically synchronized with the color transparancies. The study guide and post-test were written.

Computer-assisted-instruction was incorporated into three of the minicourses. Computer simulations[3] were used as augmentations for these laboratory exercises.

Four field trips were included in the course. The field trips were assigned as minicourses. Each field trip was scheduled for three different times to accomodate the various students' schedules. One field trip, Oakland

[3] Huntington II Programs. Digital Equipment Corporation, Maynard, Massachusetts.

Museum, did not include a slide-tape module, post-test or evaluation. This field trip was held during the last week of the semester.

Open-Laboratory

One minicourse was assigned on Monday; the experiment, study guide and post-test were due on the following Monday. Students spent as much or as little time in the laboratory as they required. The laboratory was available for the students 18 hours during the week. Each student signed into and out of the laboratory on a time card at the door. Students could obtain the study guide one week in advance.

After reading the study guide, the students watched the module. The module was set up on a portable carrel in the back of the laboratory. The carrel is shown in Figure 1. Two carrels were used, each carrel had four sets of headphones for multiple use. The laboratory format is illustrated in Appendix IV.

A student assistant was present in the laboratory at all times to help with experiments; answer questions and administer post-tests. An instructor was available either in the laboratory or an adjacent office.

Materials and references for the experiments were located throughout the laboratory. Students were also responsible for materials presented as demonstrations in the laboratory.

Figure 1. Student using slide-tape module in the open laboratory.

After completing the experiment and all of the questions in the study guide, the students turned in the study guide and took the post-test. The post-test was immediately scored and returned to the student. The student then completed a minicourse evaluation.

Collection of Data

Students enrolled in classes through the second week of instruction. Students could also drop classes during this time without a W grade appearing on their records. Enrollment data at the beginning of the semester was not accurate because of the flux of students between classes. The number of students enrolled at the second census date (ninth week of instruction) was chosen as the initial enrollment for this study. College regulations prohibit students from enrolling in classes at this time; they can withdraw after this time at the instructor's discretion.

Enrollment in "Man in a Biological World" and final grades for students in "Man in a Biological World" between Spring 1975 and Spring 1977 were obtained from the Registrar's Office (see Appendix V). The number of students withdrawing after the ninth week of instruction was also obtained from the Registrar (see Appendix V).

Student scores on study guides, post-tests and three examinations were used to determine final grades for the Fall 1977 class.

A summative student evaluation of the laboratory portion of "Man in a Biological World" was taken at the end of the Spring 1977 semester. The Fall 1977 students completed the same summative evaluation (see Appendix II).

The number of hours each student spent in the laboratory was recorded on student time cards.

Treatment of Data

Chi Square was used on the initial enrollment to compare each semester from Spring 1975 through Fall 1977. The expected enrollments for each semester were used as the expected frequencies for this test.

The attrition rate for each semester was calculated by dividing the number of students who withdrew after the ninth week of instruction by the initial enrollment. A two sample test of population proportions was used to compare the attrition rates using conventional instruction and auto-tutorial instruction. The average attrition rate for "Man in a Biological World" using conventional instruction (Spring 1975 through Spring 1977) was compared to the attrition rate during the Fall 1977 semester (auto-tutorial instruction).

The enrollment and attrition for each semester (Spring 1975 through Fall 1977) were illustrated in graph form (see Figure 2).

Chi Square was performed to compare the final grades of students receiving conventional instruction in "Man in a Biological World" (Spring 1975 through Spring 1977) and students receiving auto-tutorial instruction (Fall 1977). The expected frequencies for final grades were skewed to the right towards grades of A and B. This was done because few grades of D and F were given during any semester of "Man in a Biological World." Therefore the grades were not randomly distributed over a bell-shaped curve.

The final grades received by students in "Man in a Biological World" were illustrated in a graph (see Figure 3) to compare grades received during each semester. The average grades given to students receiving conventional instruction were compared to the grades received by auto-tutorial students in a graph in Figure 4. The grade point averages for conventional students and auto-tutorial students were calculated. The grade point average was calculated using the following system

A = 4 points
B = 3 points
C = 2 points
D = 1 point
F = 0 points

The class grade point average (GPA) was calculated by this formula with "N" equalling the number of students receiving final grades

$$GPA = \frac{4(\#A) + 3(\#B) + 2(\#C) + 1(\#D)}{N}$$

The grade point averages for conventional students and the auto-tutorial class were calculated.

The average scores achieved on study guides, post-tests and laboratory totals (study guide + post-test) were calculated for each minicourse used during the Fall 1977 semester. The average scores were illustrated in a bar-graph in Figure 5. A score of 70 percent or above on the study guide, post-test or laboratory total was established as acceptable achievement for the purposes of evaluating student performance on each minicourse. Although there are variations in the grading systems and policies used by different instructors, all instructors in "Man in a Biological World" include 70 percent in the C range.

Student responses on the course and minicourse evaluations were tallied. To interpret the student responses on the evaluations, 67 percent of the students stating that they "Agree" or "Disagree" on a particular item was established as significant. Sixty-seven percent is a clear majority with students in agreement two-to-one.

A bar-graph was used to represent the comparison between the student responses to questions #7 and #8 on the course evaluation for the Spring 1977 and Fall 1977 semesters (see Figure 6).

The students' responses on the minicourse evaluations were tallied. The responses to questions #8, #9

and #10 were graphed with the scores received for each minicourse in Figure 7.

The responses to question #12 on the course evaluation were illustrated in a graph comparing Spring 1977 and Fall 1977 responses (see Figure 8).

The number of hours per week each student spent in the laboratory was calculated using information from the time cards. The average time spent on each minicourse was calculated. This was compared with the three-hour laboratory period used during previous semesters by a two sample test of population proportions.

The number of hours per week spent in the laboratory was compared with the final grades received by the students in Table 2. The number of hours per student per week was determined and the average determined for students receiving grades of A, B, C, D and F. The Spearman-Rank order correlation was used to compare final grades with the amount of time spent in the laboratory. A comparison was made between the time spent in the laboratory by auto-tutorial students and the time spent by conventional students and the final grades that they received.

A graph (see Figure 9) was used to compare the laboratory total score and the actual number of hours (time cards) spent in the laboratory and the number of hours reported by the students on the minicourse evaluation.

The student responses on the minicourse evaluations were aggregated into major categories, i.e., objectives, study guide, audio and visual (see Table 3).

A bar-graph (see Figure 10) presents the comparison of the final course evaluation of the Spring 1977 and Fall 1977 students.

The laboratory exercises were ranked by the students during the Spring 1977 semester. Finally the exercises from the students' most to least favorite were listed. The minicourses were treated in a similar manner for the Fall 1977 semester.

FINDINGS

The enrollment and grades for all sections of "Man in a Biological World" from Spring 1975 through Fall 1977 are included in Appendix V. Conventional instruction was used for Spring 1975 through Spring 1977 classes and individualized instruction was used during the Fall 1977.

During the Fall 1977 semester enrollment in "Man in a Biological World" was 72 percent of the expected enrollment compared to an average enrollment of 44 percent during previous semesters. The initial enrollment is illustrated in Figure 2. Chi Square was used with the initial enrollment data. The results show a significant difference between the Fall 1977 enrollment and that of previous semesters at a 5 percent level of significance. It was assumed for the expected frequencies that the expected enrollments for "Man in a Biological World" should have been achieved over the five semester period.

These results indicate that the laboratory scheduled "By Arrangement" was desirable for students. They did not have to commit a three-hour block of time for a conventional laboratory course which presents a less flexible schedule, thus preventing a student from

enrolling in as many as three lecture-only courses. Counselors at Skyline College report that when presented with this choice, students prefer to take the lecture-only courses.

Student Performance

Hypothesis #1: "Individualized instruction has no effect on initial enrollment in 'Man in a Biological World'" was rejected. An alternate hypothesis was accepted: individualized instruction had a positive effect on initial enrollment in "Man in a Biological World." Thus it can be assumed that individualized instruction allows more students to fulfill their general education requirements with a laboratory life science course.

The attrition rate during the Fall 1977 semester was 5 percent. An average of 27 percent of the students enrolled during previous semesters withdrew prior to the final examination. There were no differences in the withdrawal procedures of the instructors during each of these semesters. The attrition rate for each semester is shown in Figure 2. A two sample test of population proportions showed that a significant difference (at 0.05 level of significance) existed between the attrition rate of Fall 1977 and previous semesters.

Hypothesis #2: "Individualized instruction has no effect on the attrition rate in 'Man in a Biological

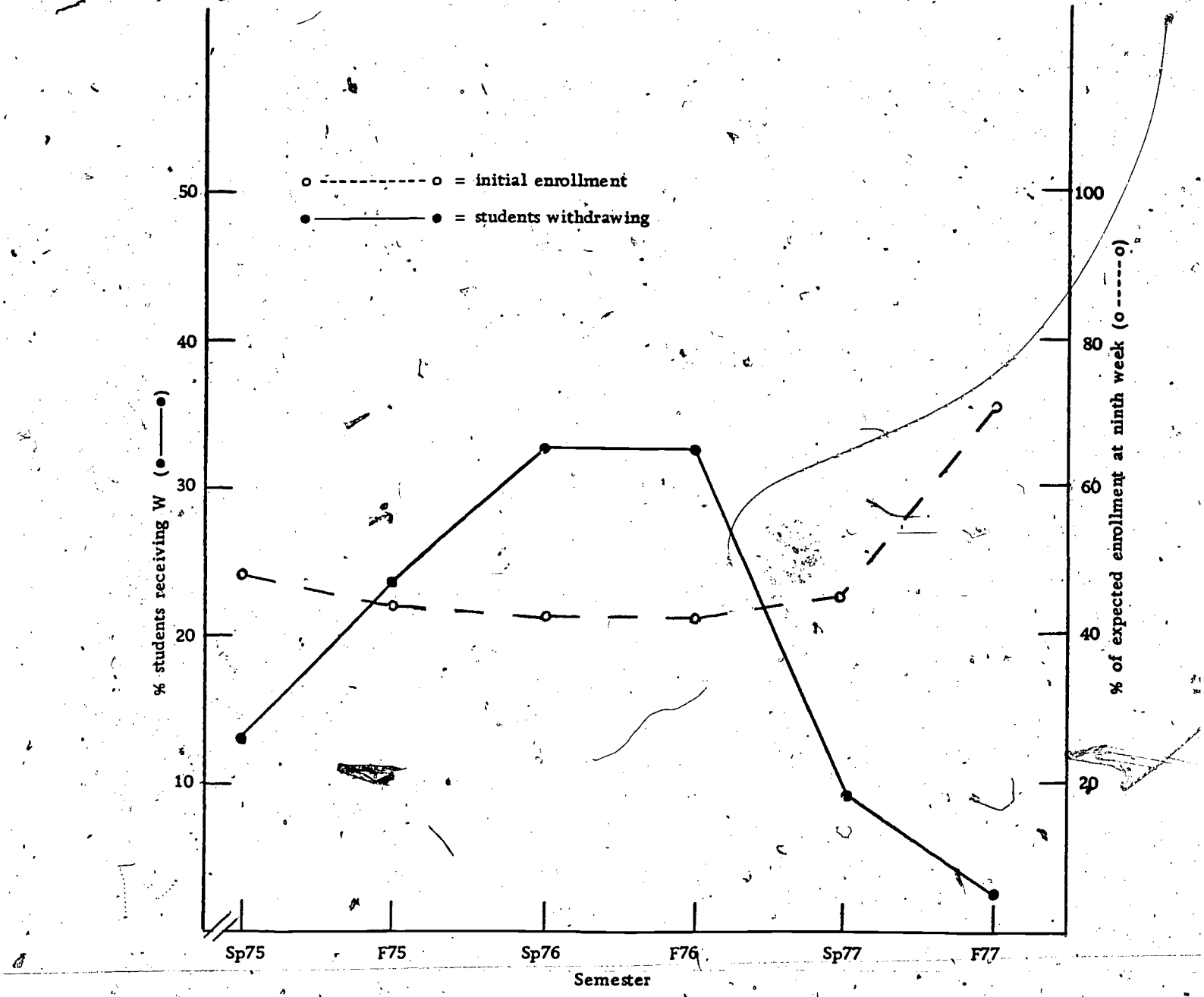

Figure 2. A comparison of the initial enrollment and the attrition rate in "Man in a Biological World" using conventional instruction (Spring 1975 - Spring 1977) and individualized instruction (Fall 1977).

World'" was rejected. The alternate hypothesis was accepted: Individualized instruction increases the retention of students in "Man in a Biological World."

The 95 percent retention of students receiving individualized instruction is attributed to the following factors.

1. Students feeling they could succeed because they were given sufficient time and opportunity to complete each minicourse.

2. Students liking being responsible for their own learning and thus being motivated.

3. Students finding minicourses "interesting" and a stimulus to continue in the course.

The final grades received by students in "Man in a Biological World" are shown in Figure 3. The average grade distributions using conventional instruction and individualized instruction are compared in Figure 4. There were more A, D and F grades given to students receiving individualized instruction. Chi Square performed on the grades received by students in "Man in a Biological World" between Spring 1975 and Fall 1977 showed that there was a significant difference between conventional and auto-tutorial students at the 5 percent level of significance. Expected frequencies used in Chi Square were skewed to the right towards higher grades. The expected frequencies employed in this test were

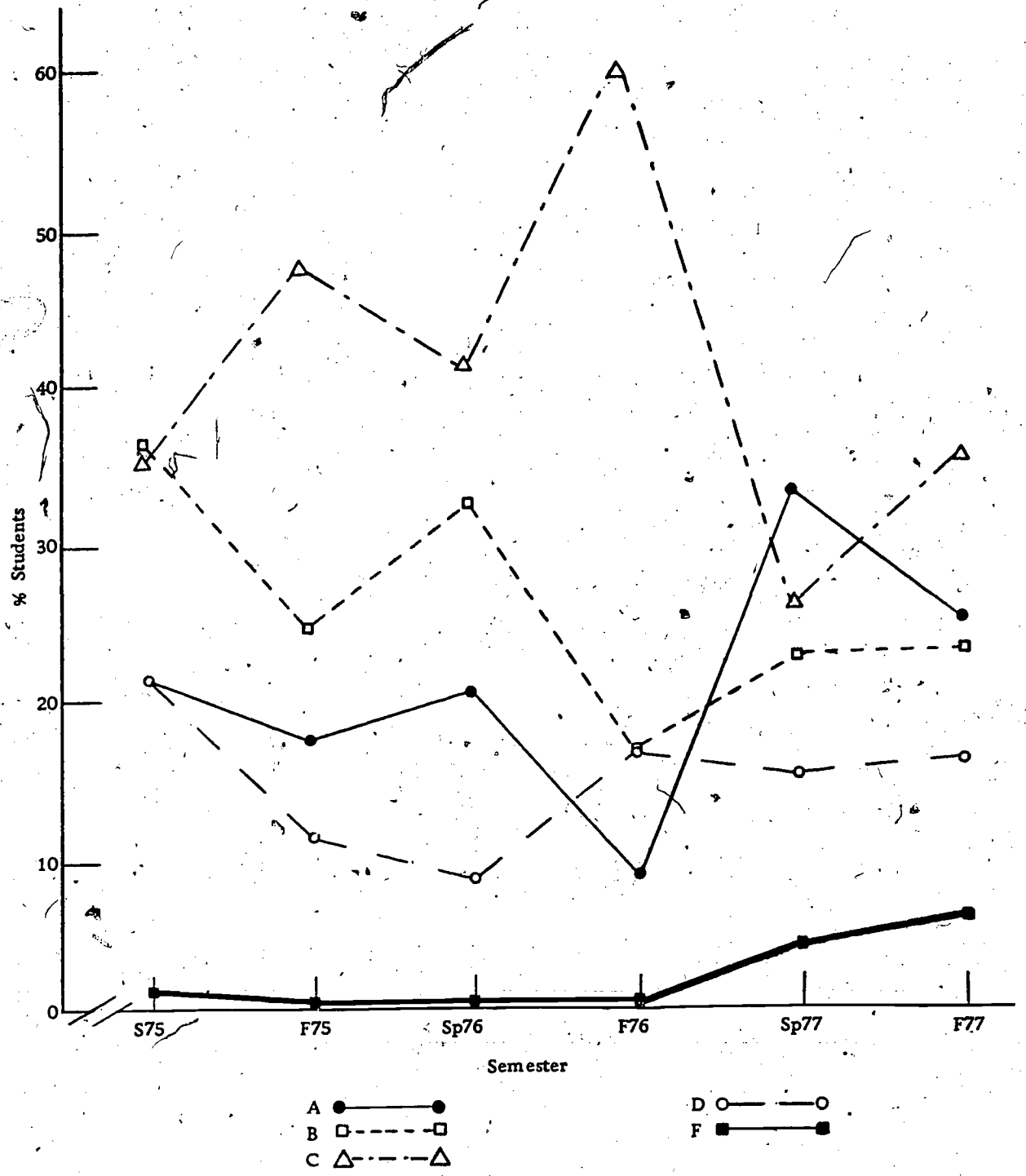

Figure 3. Final grades received by students in "Man in a Biological World" between Spring 1975 and Fall 1977.

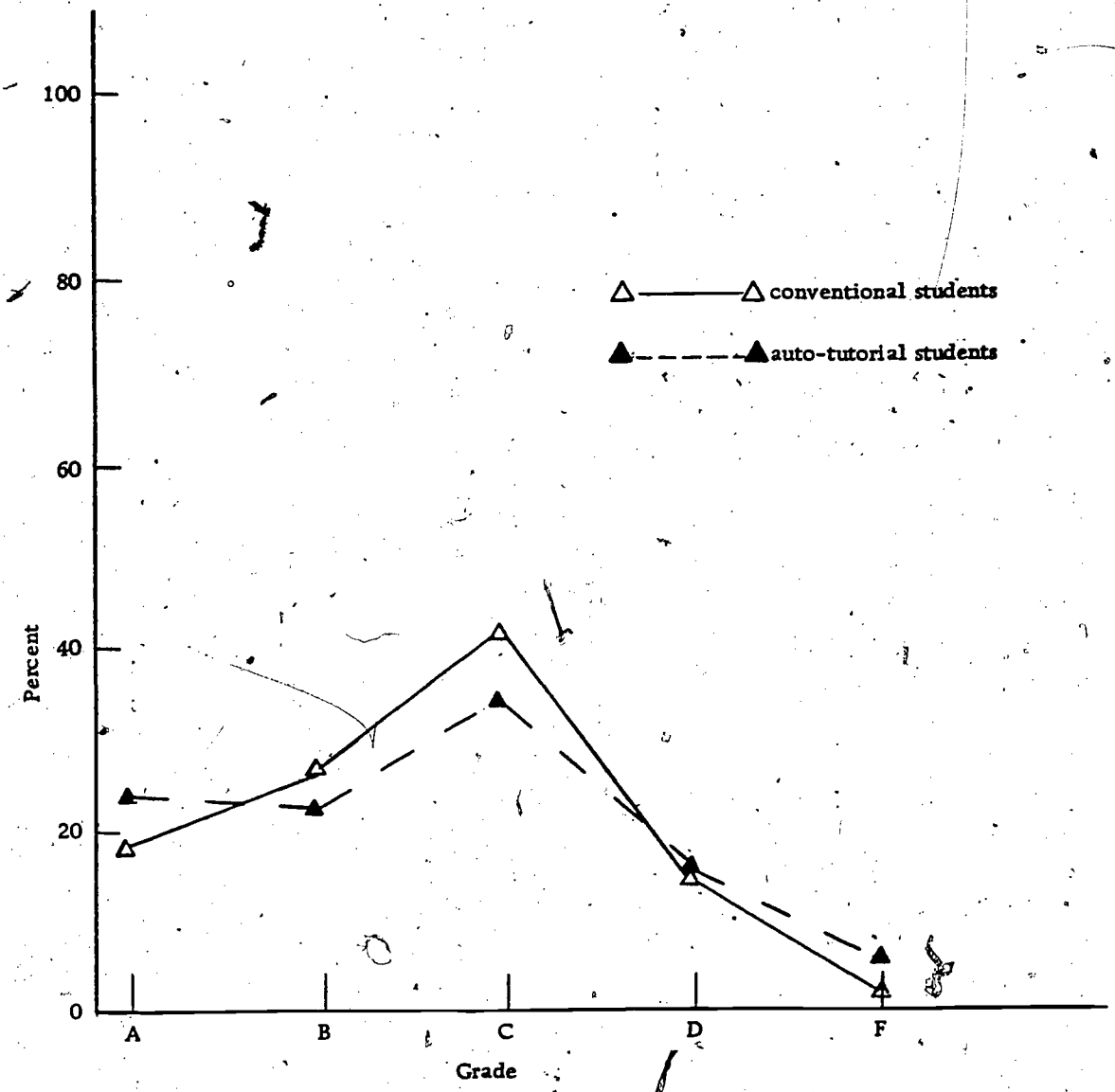

Figure 4. Comparison of average grades received by conventional students and auto-tutorial students in "Man in a Biological World".

20 percent A grades, 30 percent B's, 40 percent C's, 10 percent D's and 0 percent F's. This was done to compensate for the high percentage of A's, B's and C's given in "Man in a Biological World" during the six semesters.

Hypothesis #3: Individualized instruction does not affect student achievement in 'Man in a Biological World'" was rejected. The alternate hypothesis that individualized instruction improves student achievement in "Man in a Biological World" was accepted.

It should be noted that certain students appear to have done poorly with auto-tutorial instruction. This may be attributed to lack of self-motivation. Two students who received a grade of F during the Fall 1977 semester did not complete all of the minicourses. They did not spend time in the laboratory.

The grade point average in "Man in a Biological World" using conventional instruction was 2.6. Students receiving individualized instruction had a class grade point average of 2.7.

The average student score on the weekly minicourses was 76.5 percent. This had been designated as successful achievement. There were no comparable data available from previous semesters as students were not required to submit study guides for grading. Further, laboratory post-tests were not administered at this time. The average

score on the study guides for 15 minicourses was 82.3 percent and the average score on 15 post-tests was 66.7 percent. The bar-graph in Figure 5 shows the study guide and post-test scores for each minicourse. The third line is the laboratory total (study guide + post-test). With the exception of the first minicourse, the post-test scores were lower than the study guide scores. The role of student complacency on the post-tests is unknown. The question could be asked: "Did they study harder for the first post-test because they did not know what to expect?" Students generally expressed anxiety about having a post-test the first week of the semester, they were not used to being tested so soon. There was no penalty for performing poorly on the post-tests and the students could proceed with further minicourses regardless of their last score. The only requirement was that the post-test must be taken prior to the deadline for submitting said minicourse.

The results of the final course evaluations are summarized in Appendix II. The responses to question #7 and #8 are shown in the bar-graph in Figure 6. Question #7 asked the students to rate the minicourses. The students receiving individualized instruction rated the laboratory exercises 15 percent higher than the students receiving conventional instruction (Spring 1977). The study guides used in the laboratory exercises were

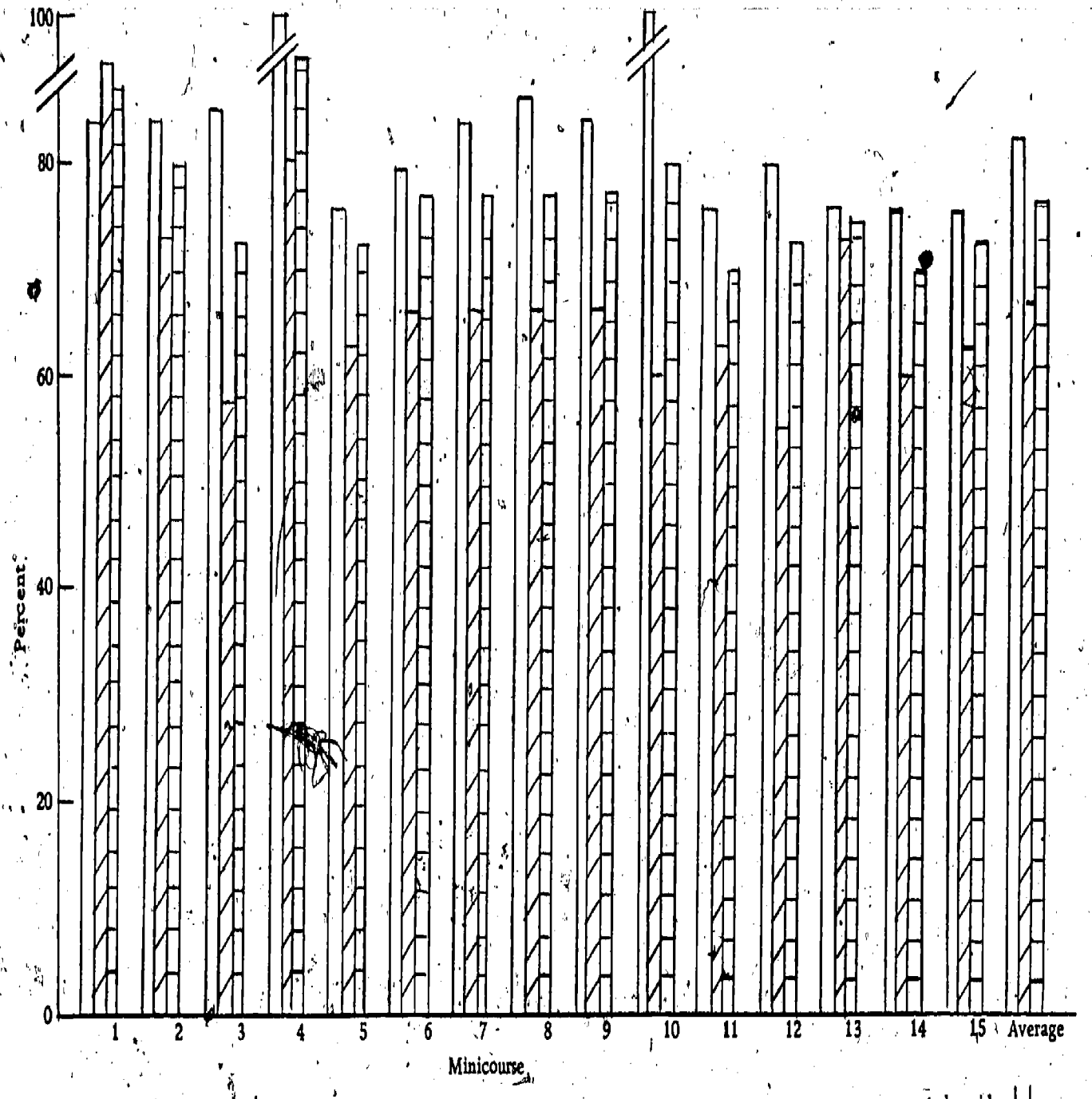

Figure 5. Comparison of average class scores on each minicourse (Fall 1977).

essentially the same for both semesters. The only modifications made in the study guides were clarifications of procedures that were necessary for students to work independently. Lists of materials and detailed outlines of procedures were added. A page for recording data and answering questions was also added. The data and questions directed the students' attention toward particular events during their experimentation. This also provided objective criteria for grading the study guides.

Students were asked to respond to the statement "The labs were stimulating" in question #8. Their responses are also shown in Figure 6. The auto-tutorial students rated the laboratory exercises 9.4 percent higher than did the conventional students. These evaluations suggest that the students respond favorably toward individualized instruction. These data indicate that the students may prefer to be in charge of their own educational experiences. The results indicate that the students were more stimulated by the method than by the subject since the subject was the same for both semesters.

There was no apparent correlation between minicourses that the students rated as relevant, stimulating or organized and their scores on that minicourse. A comparison of students' scores and evaluations is made in Figure 7.

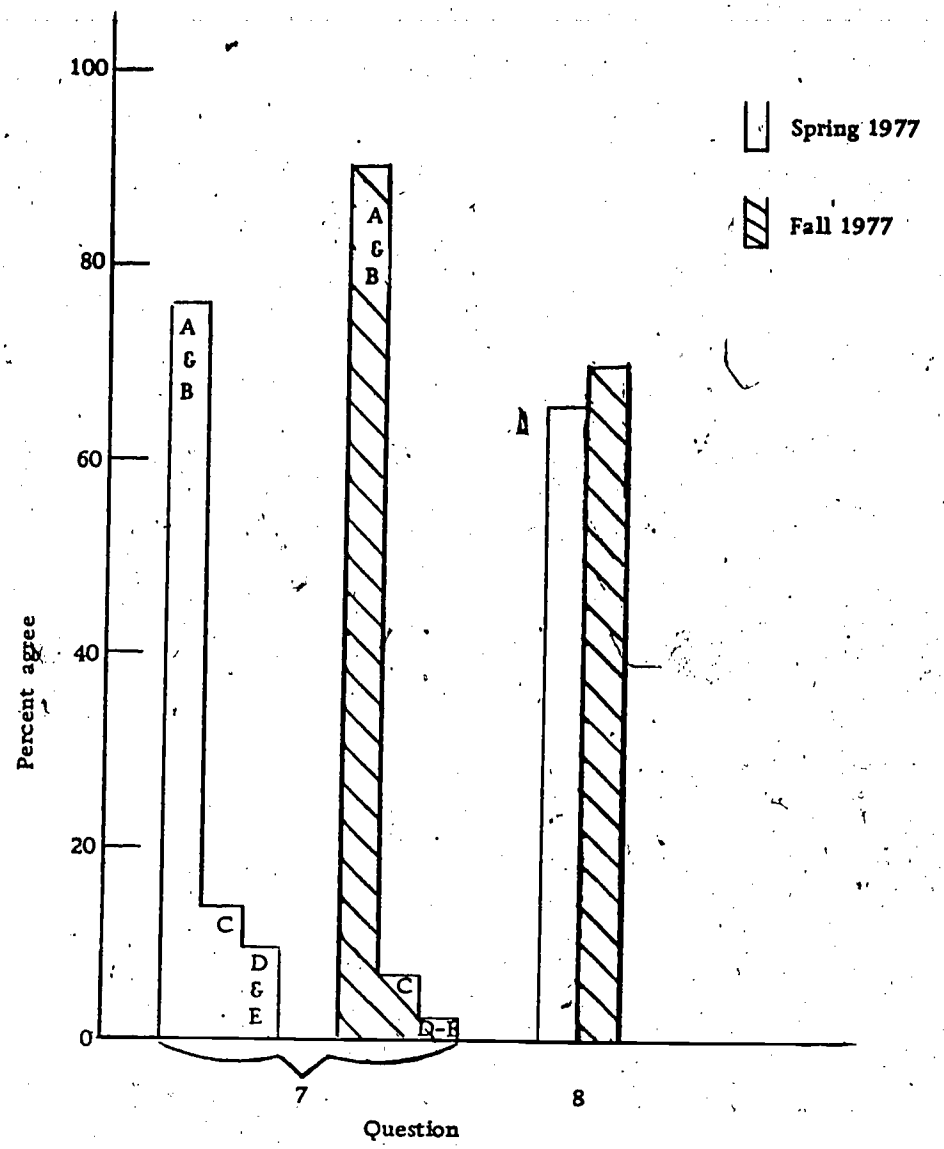

Figure 6. Comparisons of Spring 1977 and Fall 1977 student evaluation. Question 7: Overall evaluation of lab. exercises: A - excellent; B - good; C - average; D - below average; E - poor. Question 8: Found labs. stimulating.

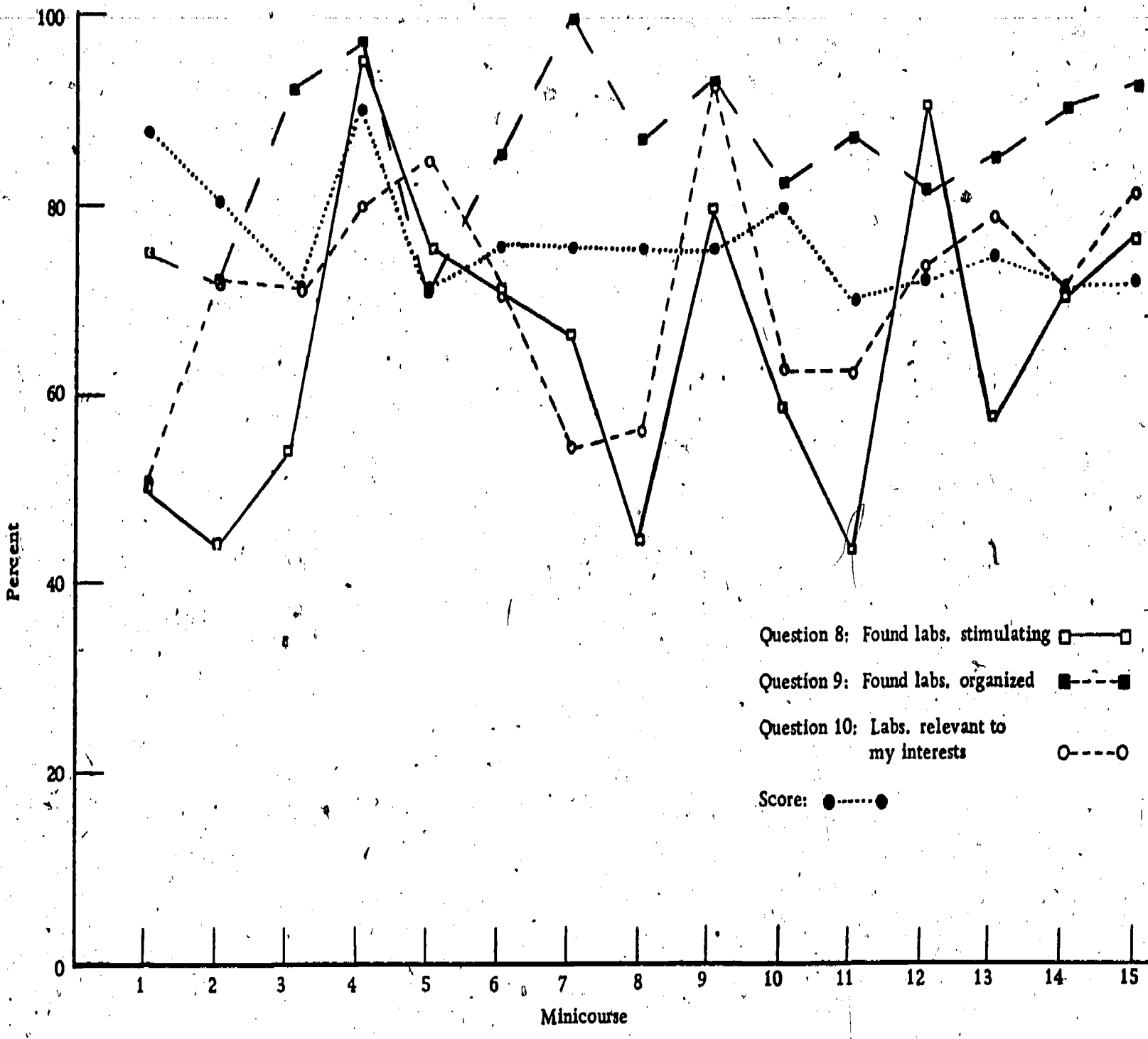

Figure 7. Comparison of average scores on minicourses and student evaluations of minicourses) (Fall 1977).

Hypothesis #4: "Students in 'Man in a Biological World' were indifferent toward individualized instruction" was rejected due to the information obtained in the course evaluation. Clearly they found the laboratory exercises more stimulating and of overall better quality with individualized instruction as shown in their responses to questions #7 and #8. This qualitative evidence suggests that the students were not indifferent. However, responses to question #12 are not clear as to whether students prefer individualized or conventional instruction.

Question #12 asked the students whether they prefer a scheduled three hour laboratory or individualized instruction. The responses to this question are illustrated in Figure 8. It was assumed that the students in each group had no prior experience with the other mode of instruction which meant that they could not understand the question. The students receiving conventional instruction stated that they preferred this method. Because of their unfamiliarity with individualized instruction it could be assumed that they thought they would just to to the laboratory with the study guides as they were prepared for use in a conventional laboratory where an instructor leads them through the experiment. Responses from students receiving individualized instruction were 39 percent preferring a scheduled three hour laboratory and 45 percent preferring individualized instruction. An A or B student

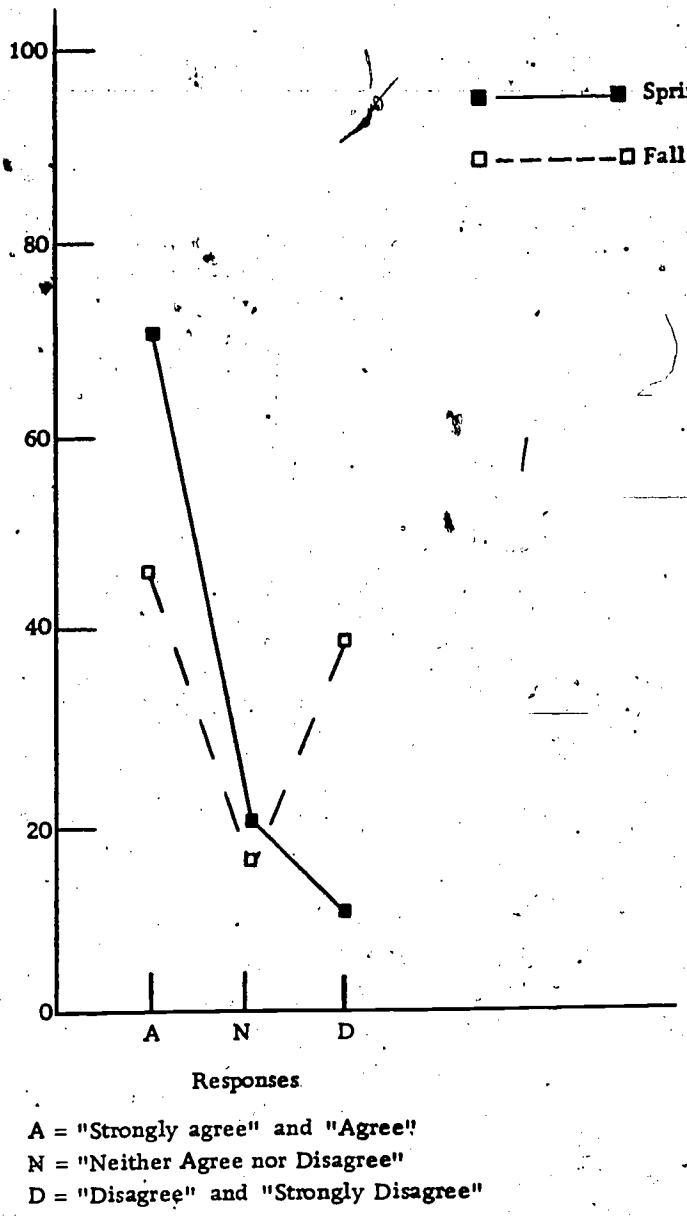

Figure 8. Comparison of auto-tutorial and conventional students' responses to question 12: Would like to do the lab. exercises during a scheduled 3-hours lab. period rather than independently.

who spent more than three hours in the laboratory could have been responding to the time factor in the question. Such a student would be indicating that three hours are preferable to six hours rather than responding to the type of instruction. According to a first-day questionnaire, students in "Man in a Biological World" had had no prior college laboratory experience and did not know from experience what a scheduled laboratory was and therefore the judgement required in question #12 could be less valid.

Students receiving conventional instruction in "Man in a Biological World" were permitted to spend no longer than three hours a week in the laboratory. However, less than three hours was permissable. In this group some students completed the assigned exercise and others left before they had completed the assignment.

The time spent in the laboratory by students receiving individualized instruction is listed in Table 2. The average time per week was 3.7 hours per student. Students receiving grades of A, B and C spent more than three hours in the laboratory each week; the average of these students was 4.6 hours. Students appeared to expand into the available time rather than efficiently completing the assigned exercises. However, better achievement was demonstrated with individualized instruction as was discussed above.

Table 2. Comparison of time spent in the laboratory and final grades.

Grade	Average Number of Hours per Week per Student	Average Hours Per Week C or Better Students
A	5.6	
B	3.9	4.6
C	4.2	
D	2.5	
F	2.3	
Average	3.7	

Figure 9 compares the time spent on each minicourse as recorded on the time cards with the hours reported by the students on the minicourse evaluations. Students signed into and out of the laboratory on time cards. The time cards were a record of the time actually spent in the laboratory. Students were asked to report the number of hours spent on a minicourse on the evaluation. In general, the students spent more time in the laboratory than they reported on the minicourse evaluation. They spent time in the laboratory studying or discussing their results with other students and did not record this as actual time spent working on the exercise.

Hypothesis #5: Individualized instruction does not affect the length of time students spend in the

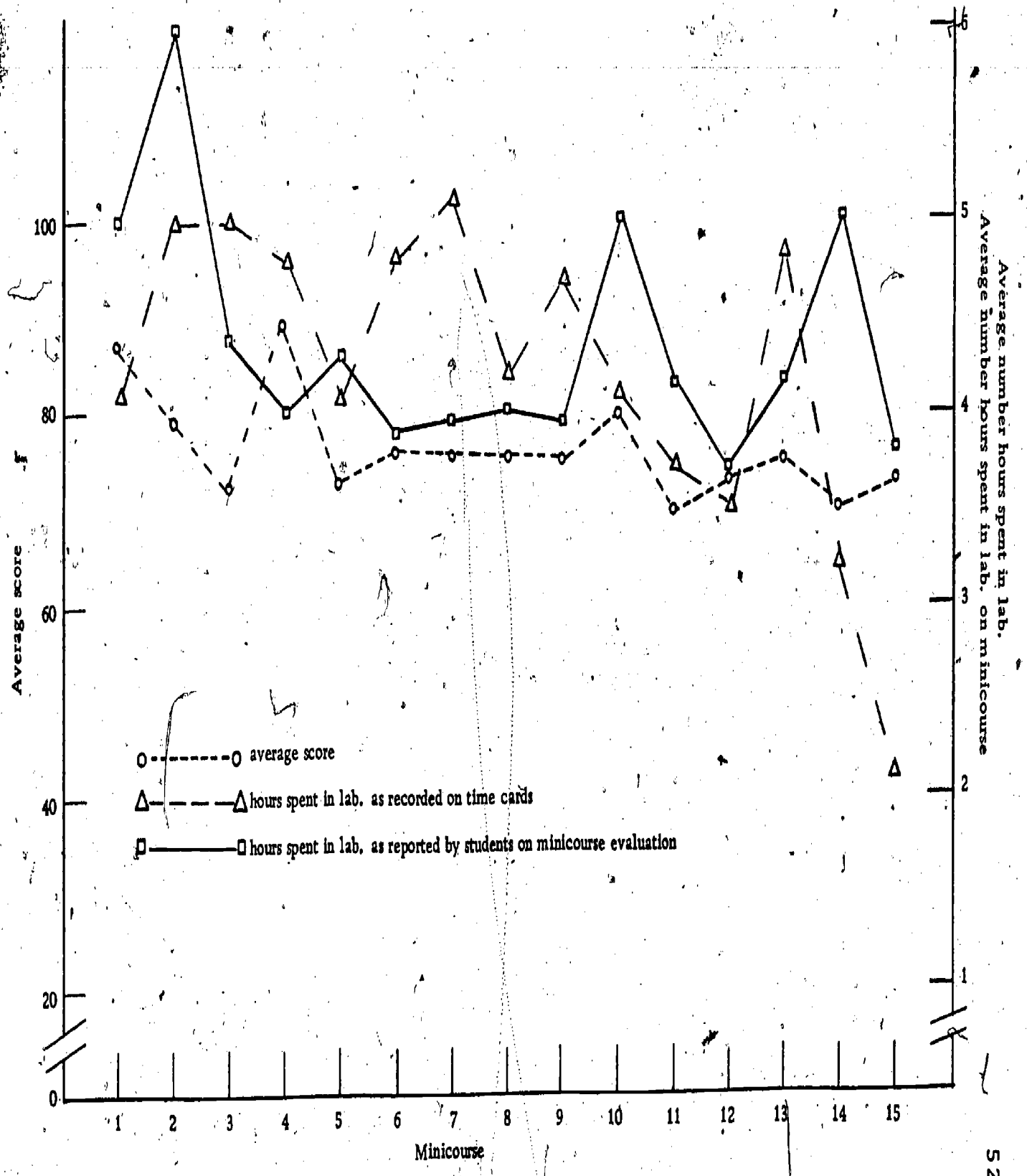

Figure 9. Comparison of scores on minicourses with time spent on each minicourse.

laboratory" was rejected. Students receiving individualized instruction increased their time spent in the laboratory. Auto-tutorial students spent significantly more time in the laboratory as shown by a two sample test of population proportions at a 5 percent level of significance.

Hypothesis #6: "Final grades are not proportional to the length of time spent in the laboratory" was rejected. Students receiving grades of A, B and C spent more than three hours in the laboratory; whereas students receiving D's and F's spent less than three hours in the laboratory. There is a correlation at a 5 percent level of significance between time spent in the laboratory and final grades using the Spearman-Rank order correlation.

Minicourses

Results of the minicourse evaluations are included in Appendix I. The results are summarized in Table 3. The student evaluations were used to improve subsequent minicourses. Each minicourse was produced during the Fall 1977 and completed 7 to 10 days before the students were to use it. The students' evaluations were taken into consideration for the next minicourse to be produced.

Hypothesis #7: "The stated objectives were not achieved" was rejected. The alternate hypothesis that the stated objectives were achieved was accepted. Questions one through three on the minicourse evaluation

Table 3. Summary of student responses on minicourse evaluations.

Statement	Percentage Agree*	Hours*
1. Objectives were clearly stated and achieved.	90.0	-
2. Audio was clear and easy to follow.	68.6	-
3. Study guide was clear.	80.5	-
4. Visuals were effective.	79.6	-
5. Minicourse was stimulating.	65.4	-
6. Minicourse was organized.	86.1	-
7. Minicourse was relevant.	86.1	-
8. Time spent on minicourse	-	4.00

*These figures are averages of all the responses to all of the minicourses. Data were taken from the evaluation results in Appendix I.

related to the objectives. Ninety percent of the students agreed that the objectives were clearly stated and achieved.

Hypothesis #8: "The audio presentation was unclear" was accepted. Questions four through eight on the minicourse evaluation related to the audio presentation of the module. Only 68.6 percent of the students agreed that the audio was clear and easy to follow. Three persons recorded the different minicourses. No one individual was rated high or low by the students. The audio portion of the following minicourses were each recorded by a different person.

Minicourse	Percentage Agree
Plant Community Field Trip	61.0
Experimenting with the Scientific Method	60.9
Intertidal Field Trip	63.3

It would appear that the subject matter was not the reason for poor audio evaluations because Plant Community and Intertidal were rated by the students as the overall best minicourses and their favorite topics (see Appendix II) and were rated low on audio quality.

The playback recorders used in the laboratory are rated "student grade" and a definite difference in quality was noted between these machines and those designed for technical production. The students are accustomed to eight-track stereophonic sound systems. The question then

arises: were students responding to the difference in quality in the monaural playback recorders in the laboratory?

Hypothesis #9: "The study guides were not effective" was rejected. Eighty percent of the students agreed that the study guides were clear. The alternate hypothesis: The study guides were effective was accepted.

Hypothesis #10: "The visuals were not effective in contributing to learning the material presented" was rejected. The color transparencies were effective for 79.6 percent of the students. It should be stated that basically the students are not familiar with the criteria for evaluating the technical quality of the slides. It would appear that they responded to the effectiveness of the slides in clarifying material presented in the audio and the study guide. The visuals in this minicourse were not rated differently from other minicourses despite the fact that according to the technical consultant for audio-visual work at Skyline College, the visuals in the Water Pollution module were of poorer quality than the other modules. This was attributed to difficulty in obtaining duplicate slides. The original slides for each minicourse were kept as masters. Two copies of each were made for use in the laboratory. The visuals in the Intertidal Field Trip module were rated higher than others. Three slides were of animals, and this suggests that th

students rated the visuals according to their interest in a particular topic. The Intertidal Field Trip was the favorite minicourse of the Fall 1977 student evaluation (see Appendix II-B).

Hypothesis #11: "The minicourses were neither stimulating nor relevant" was rejected. The alternate hypothesis that the minicourses were stimulating and relevant was accepted. The minicourses were evaluated as organized and relevant by 86 percent of the students. Sixty-five percent of the students indicated that the minicourses were stimulating. The responses to question #15: "The minicourses were stimulating" varied with the minicourse topic. Table 4 shows the wide variation in responses to this question.

Student Evaluation of Conventional and Auto-Tutorial Courses

The bar-graph in Figure 10 presents the results of the course evaluation by conventional and auto-tutorial students. Question #1: "The objectives of each laboratory exercise were clearly stated" on the course evaluation related to the objectives. Ninety-six percent of the auto-tutorial students stated that the objectives were achieved as compared to 90 percent of the students receiving conventional instruction. A major difference in the statement of objectives for each laboratory exercise. The study guides used during Spring 1977 did not have

Table 4. Responses of Fall 1977 students to question #15 on the minicourse evaluation: The minicourse was stimulating.

Minicourse	Percentage Agree
Experimenting with the Scientific Method	50
Metrics, Microscopes and Cells	44
Photosynthesis and Respiration	56
Ecological Adaptations of Tracheophytes	95
Plant Communities Field Trip	75
Water Pollution	71.4
Sewage Treatment Plant (Field Trip)	66.7
Insects and Insecticides	44
Intertidal Region (Field Trip)	80
Symbiosis	58.8
Nutrition	43.8
Pregnancy Tests and Human Heredity	90.9
Animal Fertilization and Development	58
Effect of Drugs on the Frog's Heart	70
Controlling Infections	77

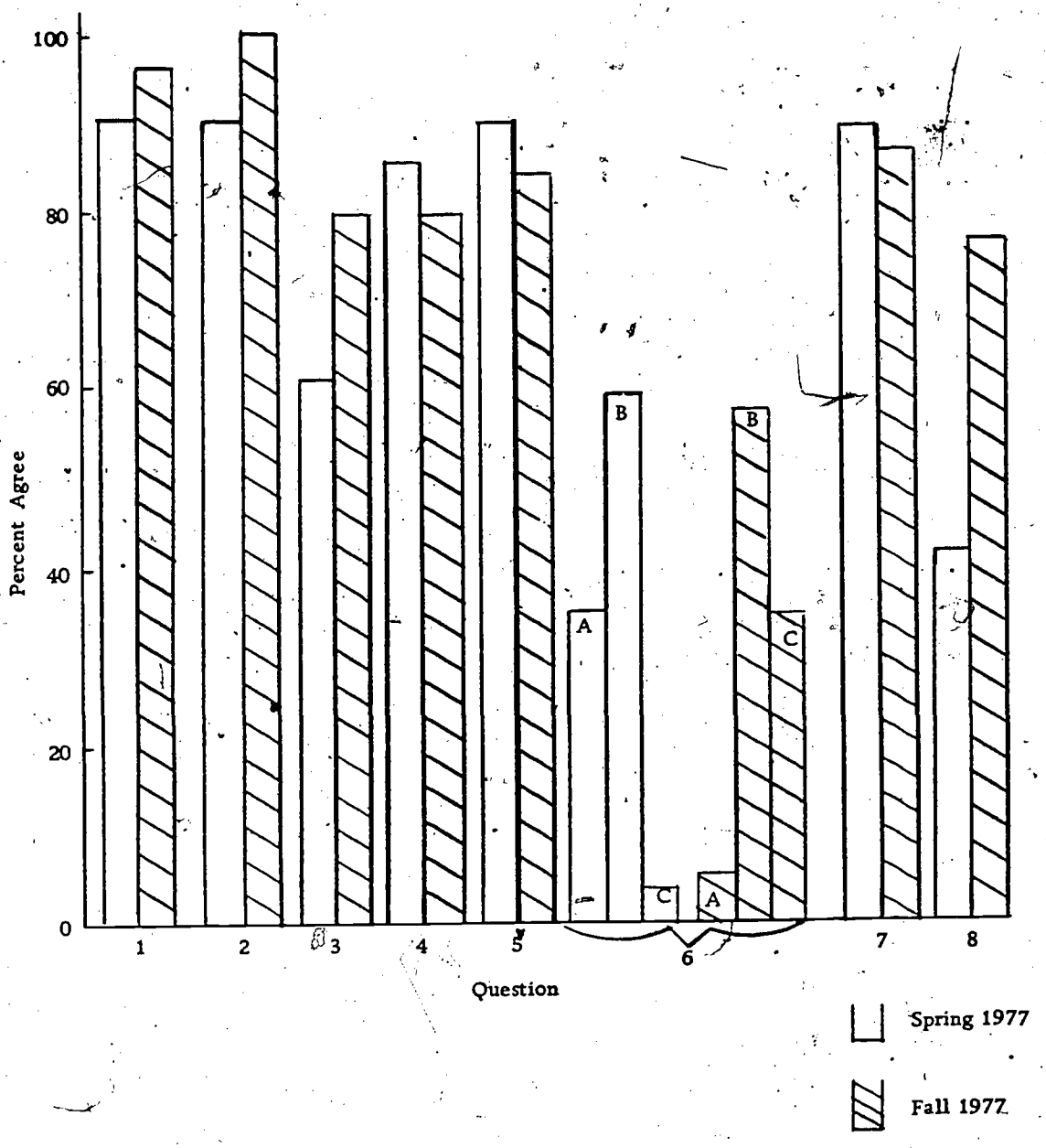

Figure 10. Comparisons of Spring 1977 and Fall 1977 student evaluations (questions 1-6, 9 and 10).

stated objectives therefore the students would not know whether the objectives had been met. Only the Plant Community Field Trip was rated low by the auto-tutorial students. This study guide did not include a statement of objectives. Rather the objectives were distributed separately on the field trip and were not received by all students. This format for the objectives was seen as confusing.

Question #2 asked whether the material presented was related to the objectives. One hundred percent of the auto-tutorial students agreed with this statement; 90 percent of the conventional students agreed. The laboratory exercises were the same for each group of students. However the conventional students were not provided with a list of objectives. They could not compare the information presented with the objectives, therefore their responses on this question are not valid.

Question #3 asked the students whether the objectives for each laboratory exercise were achieved. Eighty percent of the auto-tutorial students said that the objectives were achieved compared to 61 percent of the conventional students. Again the conventional students did not have objectives and they were uncertain as to the goals of each laboratory exercise.

Eighty-six percent of the conventional students agreed that the instructions for each exercise were clear

and easy to follow (question #4) compared to 80 percent of the auto-tutorial students. The auto-tutorial students were provided with exact procedural steps. The conventional students received the procedural information verbally from the instructor. This lower agreement by the auto-tutorial students is seen by the author as a reflection of their having to work independently. The instructions in the minicourses were more clear than in the conventional study guides. However, leaving students to work independently can mean they will experience some confusion while they establish their priorities for laboratory work. This was indicated during the first three weeks of the semester.

The students spent an average of 4.7 hours per week in the laboratory during the first four weeks compared to 4.0 hours per week for the remaining eleven weeks. It is assumed that as the students became more familiar with individualized instruction they became more efficient in the use of their time. In a conventional laboratory course the instructor goes through the experiment step-by-step. In an auto-tutorial course the students must determine what they will do on their own.

Question #5 asked the students whether the laboratory exercises were effective and contributed to understanding the subject. Ninety percent of the conventional students agreed compared to 84 percent of the auto-tutorial

students. Again, this reflects the students having to work independently and to be responsible for their laboratory experiments.

The volume of work required in laboratory was generally reported to be appropriate by both groups of students. Fifty-nine percent of the conventional students and 59 percent of the auto-tutorial students agreed that the volume of work was appropriate (question #6). This question was asked of the Spring 1977 students; 36 percent said too little work was required and 5 percent said too much work was required. In past experience with instructor evaluations at Skyline College it was unusual for any students to respond that too little work was required.[4] Because 36 percent of the students felt that too little work was required in the laboratory exercises, materials were added to each of the laboratory exercises during preparation of the minicourses to extend the learning potential. Appendix III contains a list of the minicourses and additions that were made to the minicourses. For example, the conventional laboratory on Primary Productivity was expanded to include respiration. A computer simulation was added to the Water Pollution laboratory. This resulted in the Fall 1977 class responding on the

[4]Science-Mathematics-Technology Division Director's file of instructor evaluations, 1975 through 1978.

course evaluation; 6 percent stating that too little work was required and 35 percent stating that too much work was required. It cannot be determined whether too much was required because the students did not have standards for evaluation. However, the condition of having "too little work" was adjusted.

The laboratory exercises were seen as organized by both groups of students (question #9). Ninety percent of the conventional students and 87 percent of the auto-tutorial students agreed that the laboratory exercises were organized. Question #10 asked whether the laboratory exercises were relevant. Forty-two percent of the conventional students agreed that the laboratory exercises were relevant; 78 percent of the auto-tutorial students agreed. The laboratory exercises were the same for both classes. However the presentations differed and the auto-tutorial students rated the exercises 53 percent more relevant. These data would appear to support Brewer (1974) in that the presentation in a conventional laboratory class depends on the instructor; and if the instructor is disinterested in a particular topic, s/he is not likely to present it to the students in a way that will interest them. The minicourses were prepared to interest the students and create a relevance in each topic using current events, the human body and local organisms.

At the end of the Spring 1977 semester and the Fall 1977 semesters students were asked to rate the laboratory exercises from their most to their least favorite (see Appendix II). There was no correlation between those laboratory exercises that were the "favorite" and other criteria used on the course evaluation. Ecological Adaptations of Tracheophytes was rated as the least favorite. Yet, this laboratory exercise was rated high on the minicourse evaluation. A summary of the evaluation of this minicourse is shown in Table 5. This was the fourth minicourse during the sixteen week semester. The results suggest that the students did not remember the earlier minicourses because the first and second week minicourses were also rated as lesser favorites.

The field trips were at the top of the evaluation in both semesters. The students stated in the course evaluation that they enjoyed seeing "real-life" situations and enjoyed doing something out of the classroom (see Appendix II-A and II-B, student responses to question #13). It is recommended that field trips should be maintained as part of this course.

The students were asked to write comments on the course evaluation (question #12). No comments were received from conventional students. This reflects the failure of the course to involve the students. The comments received from auto-tutorial students made

Table 5. Summary of student evaluation of Ecological Adaptations of Tracheophytes minicourse. Data expressed in percentages.

Minicourse	Percentage Agree
Responses Immediately After Completing the Laboratory Exercise	
Objectives were clearly stated and achieved.	100
Audio was clear and easy to follow.	83.4
Study guide was clear.	83.4
Visuals were effective.	85
Minicourse was stimulating.	95
Minicourse was organized.	97
Minicourse was relevant.	80
Response at the End of the Semester	
Rated #16 least favorite laboratory exercise	

reference to the lecture in their evaluation of the laboratory (see Appendix II-B, responses to question #12). This made interpretation of the student evaluations difficult because they were including their perceptions of the lecture and the instructor in the laboratory evaluation. The students did not separate their evaluation of the laboratory from their evaluation of the entire course.

The analysis of grades and time spent in the laboratory provides the most concrete data regarding the effectiveness of auto-tutorial laboratory instruction. The results clearly show that student performance was improved during the Fall 1977 semester. It is intended that the continued use of these minicourses will insure that the students get a uniform presentation and will have the relevance and interest created.

SUMMARY AND CONCLUSIONS

Envollment, retention and achievement in "Man in a Biological World" were low using conventional instruction (Spring 1975 through Spring 1977). During the Fall 1977 semester, individualized instruction was used in the laboratory portion of "Man in a Biological World." The class was scheduled with three lecture/discussion hours per week and laboratory "By Arrangement."

The purpose of this study was to determine the effects of individualized instruction in laboratory with regard to enrollment, retention, achievement and students' attitudes. Data from the classes receiving conventional instruction was compared to that gathered during the Fall 1977 semester using auto-tutorial instruction. It was assumed for this study that conventional instruction was the reason for poor student achievement in "Man in a Biological World" during the Spring 1975 through Spring 1977 period. Further it was assumed that the student groups compared in this study were the same as to their background in science courses, experience in college and grade point averages. Limitations accepted were that only the laboratory portion of the course was modified for individualized instruction and conclusions could

therefore be based on the effects of auto-tutorial laboratory instruction. Another limitation was that the initial student enrollment in classes at Skyline College was influenced by counselor bias. It was then further assumed that retention during the Fall 1977 semester was not affected by enrollment practices.

Fifteen minicourses were developed and used in the laboratory portion of "Man in a Biological World." Each minicourse included:

1. A printed study guide.
2. A slide-tape module.
3. Laboratory experiments.
4. A grade Option Activity for A and B grades.
5. A 15 point objective post-test.
6. An evaluation.

One minicourse was assigned each week. The students worked in the laboratory at their own pace to complete the weekly assignments. The laboratory was available for the students eighteen hours during the week. A student assistant was present in the laboratory to help the students, and the instructor was also either in the laboratory or in an adjacent office. Students were required to attend three one-hour lecture/discussion sessions each week. The lecture/discussion was held in a traditional format. Final grades were determined on the basis of study guide score, post-test scores and three examinations held during the lecture period.

Enrollment data and final grades for the sections of "Man in a Biological World" offered between Spring 1975 and Spring 1977 were obtained from the Registrar and were used to assess quantitatively the effectiveness of individualized instruction. The 5 percent level of significance was used for all statistical analyses.

The Spring 1977 students who had conventional instruction and the Fall 1977 auto-tutorial students were asked to complete a final course evaluation. This information was used to ascertain qualitatively the students' opinions and attitudes about conventional and auto-tutorial instruction.

This project resulted in acceptance of the following hypotheses.

Hypothesis #1: Individualized instruction has a positive effect on initial enrollment in "Man in a Biological World.".

Hypothesis #2: Individualized instruction increases the retention of students in "Man in a Biological World.".

Hypothesis #3: Individualized instruction improves student achievement in "Man in a Biological World."

Hypothesis #4: Students in "Man in a Biological World" were not indifferent toward individualized instruction. The auto-tutorial students found the laboratory exercises more stimulating than did conventional students.

Hypothesis #5: The amount of time spent in the auto-tutorial laboratory varied with the student as opposed to an assigned three-hour laboratory period with conventional instruction.

Hypothesis #6: Final grades were proportional to the length of time spent in the laboratory. That is grades of A and B were achieved by those students who spent more than three hours per week in the laboratory.

The students completed a minicourse evaluation each week. The responses on these evaluations were summarized and 67 percent agreement by the students on a particular item was established as significant. Minicourse evaluations resulted in accepting the following hypotheses:

Hypothesis #7: The stated objectives were achieved.

Hypothesis #8: The audio presentation was not clear and easy to follow.

Hypothesis #9: The study guides were effective.

Hypothesis #10: The visuals were effective.

Hypothesis #11: The minicourses were stimulating and relevant.

In an overall rating of the laboratory exercises the conventional and auto-tutorial students ranked the outdoor field trips as their most favorite exercises. Laboratory exercises at the beginning of the semester were rated among the least favored exercises. It would

appear that students did not remember these earlier exercises. Field trips were found to be desirable and requested as part of a future course.

The auto-tutorial approach is a viable means of laboratory instruction in "Man in a Biological World." Student enrollment, retention and achievement were improved using individualized instruction. The students' attitudes were positive toward the auto-tutorial approach. Course evaluations showed that the auto-tutorial students rated the laboratory exercises 9.4 percent more stimulating and 53 percent more relevant than did the conventional students. The laboratory exercises were the same for both classes. Therefore, it would follow that the students were responding to the method. Their positive attitude was attributed to the following factors.

1. Students feeling they could succeed because they were given sufficient time and opportunity to complete each minicourse.

2. Students liking being responsible for their own learning and were thus better motivated.

3. Students finding minicourses interesting and a stimulus to continue in the course.

Both groups of students were asked whether they preferred individualized or conventional laboratory instruction. The students in the conventional program preferred conventional instruction six-to-one and the auto-tutorial

students were divided one-to-one. It can be assumed that neither group had had experience with both methods of instruction and therefore could not be realistic in answering this question.

Recommendations

1. It is recommended that auto-tutorial instruction be continued in the laboratory portion of "Man in a Biological World."

2. It is recommended that more carrels be acquired. During the Fall 1977 semester as many as four students used one carrel simultaneously. This multiple-use created a time problem and detracted from the individual freedom of stopping a module for note-taking.

3. It is recommended that the laboratory be available more hours during the week to achieve a realistic "open-laboratory."

4. It is recommended that the floor plan be modified to have a sign-in table with an automated time clock. In addition all announcements of test dates and laboratory modifications would be available at this table.

Minicourses. Multiple forms of each post-test will be written. The students will then be required to achieve a passing score on the post-test before proceeding to the next minicourse. This will better insure mastery of the material presented in each minicourse.

Dissemination. A recommendation will be made to the Director of Counseling at Skyline College for the counselors to visit the open-laboratory in order that they may gain familiarity with the biology course. This will enable the counselors to inform students about the course while students are making their course selections.

The San Mateo County Community College District includes Skyline College, College of San Mateo and Cañada College. Information regarding these minicourses will be made available to the biology faculties on all campuses so they may utilize these minicourses. The biology faculties will be invited to visit the open-laboratory at Skyline College.

Future Studies. This was the first general education science course to employ auto-tutorial instruction at Skyline College. Similar studies can be completed on other courses to determine their suitability to this method of instruction.

When other instructors employ these minicourses, analyses of enrollment, retention and achievement should be performed. The results of the course evaluation (Fall 1977) demonstrated that the students did not separate their laboratory experience from their lecture instruction (refer to Appendix II-B). Further studies should be undertaken to demonstrate the effectiveness of auto-tutorial instruction in this class regardless of instructor.

Recommendations will be made to develop minicourses that cover the lecture portion of "Man in a Biological World." This is intended to provide an integrated approach that combines audio, visual and tactile stimuli. This will provide a course through which students can proceed at their own pace where the only objective is to master the material without semester timelines.

Summary

Fifteen minicourses were developed, used and evaluated in this study. Each minicourse was a separate laboratory topic. The minicourses were not sequential and could be arranged by an individual instructor to accommodate lecture topics and individual preference. According to the student evaluations the overall quality of the minicourses was good.

A plethora of information on using auto-tutorial instruction in biology classes was found in the review of literature. There was no information available to the author on the use of auto-tutorial instruction for only the laboratory or lecture part of a course. Results of this study indicate auto-tutorial instruction can be used successfully in the laboratory while students attend a conventional lecture.

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APPENDICES

APPENDIX I

MINICOURSE EVALUATION

Auto-tutorial minicourses were developed for each of the fifteen laboratory exercises used in "Man in a Biological World." The students were requested to complete this evaluation form for each week's assignment (mini-course).

Student Evaluation Form

Dear Student,

The minicourse that you have just completed is a preliminary version and further modification requires your input. Please read each item carefully and choose the answer that comes closest to your feelings. Since we are interested in your honest evaluation, please do not write your name on the questionnaire. Circle the appropriate answer for each question.

SA = strongly agree
A = agree
N = neither agree nor disagree
D = disagree
SD = strongly disagree

Objectives

1. The objectives were clearly stated. SA A N D SD

2. The materials presented were related to the objectives. SA A N D SD

3. I feel that the stated objectives for this minicourse were achieved. SA A N D SD

Audio

4. The voice quality was clear. SA A N D SD

5. The speaker's mood was enthusiastic. SA A N D SD

6. The instructions were clear and easy to follow. SA A N D SD

7. The pacing was: A--too slow; B--slow at times; C--about right; D--fast at times; E--too fast. A B C D E

8. Overall evaluation of audio presentation: A--excellent; B--good; C--average; D--below average; E--poor. A B C D E

Study Guide

9. The written material was clearly presented. SA A N D SD

10. The study guide and tape were well synchronized. SA A N D SD

11. The pictures were effective and contributed to my understanding of the subject. SA A N D SD

Visuals

12. In general, the visuals were of excellent quality (clarity). SA A N D SD

13. The visuals were smoothly presented and integrated within the sequences of the minicourse. SA A N D SD

14. The visuals were effective in contributing to my understanding of the subject matter. SA A N D SD

General

15. I found this minicourse stimulating. SA A N D SD

16. This minicourse was organized. SA A N D SD

17. This minicourse was relevant to my interests. SA A N D SD

18. I spent approximately _____ hours on this minicourse.

Results of Minicourse Evaluations
(data expressed in percent)

The student evaluations were tallied and expressed in percent. The responses within one heading (i.e., Objectives) were averaged and recorded below.

	Agree[a]	Neither[b]	Disagree[c]
Experimenting with the Scientific Method			
1. Objectives were clearly stated and achieved (questions 1-3).	93.7	4.5	1.8
2. Audio was clear and easy to follow (questions 4-8).	60.9	20.1	19.0
3. Study guide was clear (questions 9-11).	67.0	15.5	17.5
4. Visuals were effective (questions 12-14).	65.0	7.0	28.0
5. Minicourse was stimulating (question 15).	50.0	32.5	16.7
6. Minicourse was organized (question 16).	75.0	16.7	8.3
7. Minicourse was relevant (question 17).	50.0	41.7	8.3
8. Time spent on minicourse (question 18).	5.00 hours (range 3-9 hrs.)		

[a]Strongly agree and Agree responses were included in the category Agree.

[b]Neither is used to designate neither agree nor disagree.

[c]Disagree and Strongly disagree responses were included in the category Disagree.

	Agree	Neither	Disagree
Metrics, Microscopes and Cells			
1. Objectives	77.3	13.9	8.8
2. Audio	65.0	25.8	9.2
3. Study guide	71.0	22.6	6.4
4. Visuals	70.0	24.0	6.0
5. Stimulating	44.0	52.0	4.0
6. Organized	72.0	20.0	8.0
7. Relevant	86.0	0.0	14.0
8. Time	6.00 hours (range 2-19 hrs.)		
Photosynthesis and Respiration			
1. Objectives	85.3	10.7	4.0
2. Audio	78.8	15.6	5.6
3. Study guide	81.0	12.7	6.3
4. Visuals	79.6	20.4	0.0
5. Stimulating	56.0	44.0	0.0
6. Organized	92.0	8.0	0.0
7. Relevant	71.0	25.0	4.0
8. Time	4.4 hours (range 2-12 hrs.)		
Ecological Adaptations of Tracheophytes			
1. Objectives	100.0	0.0	0.0
2. Audio	83.4	16.1	0.5
3. Study guide	83.4	10.6	6.0
4. Visuals	85.0	15.0	0.0
5. Stimulating	95.0	5.0	0.0

	Agree	Neither	Disagree
Ecological Adaptations of Tracheophytes (continued)			
6. Organized	97.0	3.0	0.0
7. Relevant	80.0	20.0	0.0
8. Time	4.00 hours (range 2-7 hrs.)		
Plant Communities Field Trip			
1. Objectives	68.0	21.3	10.7
2. Audio	61.0	30.8	8.2
3. Study guide	63.0	20.0	17.0
4. Visuals	63.0	30.0	7.0
5. Stimulating	75.0	15.0	10.0
6. Organized	70.0	15.0	15.0
7. Relevant	84.5	10.5	5.3
8. Time	4.30 hours (range 2-7.5 hrs.)		
Water Pollution			
1. Objectives	89.5	10.5	0.0
2. Audio	61.0	30.8	8.2
3. Study guide	63.0	20.0	17.0
4. Visuals	63.0	30.0	7.0
5. Stimulating	71.4	21.4	7.2
6. Organized	85.7	7.1	7.2
7. Relevant	71.4	21.4	7.2
8. Time	3.90 hours (range 2-7.5 hrs.)		

	Agree	Neither	Disagree
Sewage Treatment Plant Field Trip			
1. Objectives	98.0	0.0	2.0
2. Audio	87.5	4.6	8.2
3. Study guide	87.5	5.5	7.0
4. Visuals	82.5	10.6	6.9
5. Stimulating	66.7	20.0	13.3
6. Organized	100.0	0.0	0.0
7. Relevant	54.7	20.0	25.3
8. Time	3.96 hours (1.5-8 hrs.)		
Insects and Insecticides			
1. Objectives	86.0	9.2	4.8
2. Audio	64.8	24.0	11.2
3. Study guide	79.0	21.0	0.0
4. Visuals	77.0	14.0	9.0
5. Stimulating	50.0	31.0	19.0
6. Organized	87.0	2.0	11.0
7. Relevant	56.0	37.0	7.0
8. Time	4.00 hours (range 1-8 hrs.)		
Intertidal Region Field Trip			
1. Objectives	92.1	7.9	0.0
2. Audio	62.3	28.5	9.2
3. Study	90.2	7.8	2.0
4. Visuals	91.2	4.6	4.2
5. Stimulating	80.0	20.0	0.0

	Agree	Neither	Disagree
Intertidal Region Field Trip (continued)			
6. Organized	93.3	6.7	0.0
7. Relevant	93.3	6.7	0.0
8. Time	3.96 hours (range 1-7 hrs.)		
Symbiosis			
1. Objectives	100.0	0.0	0.0
2. Audio	63.4	31.0	5.6
3. Study guide	90.7	5.6	3.7
4. Visuals	95.9	4.1	0.0
5. Stimulating	58.8	35.3	5.9
6. Organized	82.4	11.8	5.8
7. Relevant	62.5	25.0	12.5
8. Time	5.00 hours (range 1-15 hrs.)		
Nutrition			
1. Objectives	88.9	7.4	3.7
2. Audio	62.2	30.0	7.8
3. Study guide	87.0	9.3	3.7
4. Visuals	79.0	14.4	6.6
5. Stimulating	43.8	50.0	6.2
6. Organized	87.6	6.3	6.1
7. Relevant	62.5	31.3	6.2
8. Time	4.16 hours (range 0.5-10 hrs.)		

	Agree	Neither	Disagree
Pregnancy Tests and Human Heredity			
1. Objectives	90.9	9.1	0.0
2. Audio	59.3	33.5	7.2
3. Study guide	81.8	12.1	6.1
4. Visuals	94.0	6.0	0.0
5. Stimulating	90.9	9.1	0.0
6. Organized	81.8	18.2	0.0
7. Relevant	81.8	18.2	0.0
8. Time	3.70 hours (range 0.5-10 hrs.)		
Animal Fertilization and Development			
1. Objectives	95.0	5.0	0.0
2. Audio	72.0	25.0	3.0
3. Study guide	86.7	8.3	5.0
4. Visuals	78.0	8.7	13.3
5. Stimulating	58.0	32.0	10.0
6. Organized	85.0	10.0	5.0
7. Relevant	79.0	16.0	5.0
8. Time	4.12 hours (range 2-8 hrs.)		
Effect of Drugs on the Frogs Heart			
1. Objectives	90.0	10.0	0.0
2. Audio	74.0	24.0	2.0
3. Study guide	86.7	13.3	0.0
4. Visuals	90.0	10.0	0.0

	Agree	Neither	Disagree
Effect of Drugs on the Frog's Heart (continued)			
5. Stimulating	70.0	20.0	10.0
6. Organized	90.0	10.0	0.0
7. Relevant	70.0	20.0	10.0
8. Time	5.00 hours (range 3-8 hrs.)		
Controlling Infections			
1. Objectives	95.5	4.8	0.0
2. Audio	72.8	26.2	1.0
3. Study guide	89.3	5.0	5.5
4. Visuals	88.0	7.0	2.0
5. Stimulating	77.0	23.0	0.0
6. Organized	93.0	5.0	2.0
7. Relevant	82.0	18.0	0.0
8. Time	3.80 hours (range 1.5-6 hrs.)		

APPENDIX II

COURSE EVALUATION

Dear Student,

Please complete the following evaluation of the laboratory exercises. The laboratory exercises are a preliminary version and further modification requires your input. Please read each item carefully and choose the answer that comes closest to your feelings. Since we are interested in your honest evaluation, do not write your name on the questionnaire. Circle the appropriate answer for each question.

SA = strongly agree
A = agree
N = neither agree nor disagree
D = disagree
SD = strongly disagree

1.	The objectives of each laboratory exercise were clearly stated.	SA A N D SD
2.	The materials presented were related to the objectives.	SA A N D SD
3.	I feel that the objectives for each laboratory exercise were reached.	SA A N D SD
4.	The instructions for each exercise were clear and easy to follow.	SA A N D SD
5.	The laboratory exercises were effective and contributed to my understanding of the subject.	SA A N D SD
6.	The amount of work required in lab was A--too little; B--appropraite; C--too much.	A B C
7.	Overall evaluation of the lab exercises: A--excellent; B--good, C--average; D--below average; E--poor.	A B C D E
8.	I found the labs stimulating.	SA A N D SD
9.	The labs were organized.	SA A N D SD
10.	The labs were relevant to my interests.	SA A N D SD

11. I would prefer to do the lab exercises during a scheduled 3-hr. lab period rather than independently. SA A N D SD

12. Comments:

Instructions to Spring 1977 students: Below is a list of laboratory exercises you completed during this semester. To the left of each minicourse place a 1 in front of the minicourse you like best; 2 = second best; etc; with 14 as the laboratory exercise you like least.

Instructions to Fall 1977 students: Below is a list of minicourses you completed during this semester. To the left of each minicourse place a 1 in front of the minicourse you like best; 2 = second best; etc; with 16 as the minicourse you like least.

____ Water Pollution

____ Sewage Treatment Plant (Field Trip)

____ Insect Behavior and Insecticides

____ Intertidal Region (Field Trip)

____ Symbiosis

____ Nutrition[1]

____ Animal Fertilization and Development

____ Pregnancy Tests and Human Heredity[2]

____ Effect of Drugs on the Frog's Heart

____ Experimenting with the Scientific Method

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[1]Formerly Harvesting the Sea. Minicourse was expanded to include more general nutrition information.

[2]Formerly done as two separate laboratory exercises.

___ Photosynthesis and Respiration[1]

___ Ecological Adaptations of Tracheophytes[2]

___ Controlling Infections

___ Oakland Museum (Field Trip)[3]

___ Plant Community (Field Trip)[3]

___ Metrics, Microscopes and Cells[3]

13. What did you like best about your favorite lab?

14. What did you dislike about your least favorite lab?

---

[1]Formerly Primary Productivity. Minicourse expanded to include experiments dealing with respiration.

[2]Formerly Pollination. Minicourse expanded to include general information on plants and have more "hands-on."

[3]These exercises were not used during previous semesters.

APPENDIX II-A

SUMMARY OF STUDENT EVALUATION OF BIOLOGY 4L

SPRING 1977

N = 21. All data expressed in percentages.

	Agree[a]	Neither[b]	Disagree[c]
1. Objectives of each laboratory exercise clearly stated.	90.0	5.0	5.0
2. Materials presented related to the objectives.	90.0	10.0	0.0
3. Objectives for each laboratory exercise reached.	61.0	29.0	10.0
4. Instructions for each exercise clear and easy to follow.	86.0	5.0	9.0
5. The laboratory exercises were effective and contributed to understanding subject.	90.0	10.0	0.0
6. Amount of work required in lab: A--too little; B--appropriate; C--too much.	(A) 35.0	(B) 60.0	(C) 5.0
7. Overall evaluation of lab exercises: A--excellent; B--good; C--average; D--below average; E--poor.	(A & B) 76.0	(C) 14.0	(D & E) 10.0
8. Found labs stimulating.	66.0	24.0	10.0
9. Labs were organized.	90.0	10.0	0.0
10. Labs relevant to my interests.	42.0	48.0	10.0

[a]Strongly agree and Agree responses were included in the category Agree.

[b]Neither is used to designate neither agree nor disagree.

[c]Disagree and Strongly disagree responses were included in the category Disagree.

	Agree	Neither	Disagree
11. If properly written, lab exercises could be done without instructor.	40.0	25.0	35.0
12. Would like to be able to do the lab exercises anytime during the week rather than during a scheduled lab period.	10.0	20.0	70.0
13. Comments.	None received.		

The following laboratory exercises are listed in order of preference shown by conventional students (Spring 1977). N = 21.

1. Intertidal Region (Field Trip)
2. Effects of Drugs on the Frog's Heart
3. Human Heredity
4. Pregnancy Tests
5. Water Pollution
6. Controlling Infections
7. Pollination Relationships
8. Primary Productivity
9. Harvesting the Sea
10. Symbiosis
11. Animal Fertilization and Development
12. Experimenting with the Scientific Method
13. Sewage Treatment Plant (Field Trip)
14. Insect Behavior and Insecticides

13. What did you like best about your favorite lab?

Intertidal Region

"Dealing with the subject right where it lives." (5 students)
"Interesting"
"Contemporary"
"Liked being outside" (2 students)
"Being outside and independent . . ."

Effect of Drugs on the Frog's Heart

"Working with the frog itself"
"Dissection . . . more adventure than slides"
"Dissection and watching the body parts" (2 students)

Human Heredity

"Short and interesting . . ."
"Like . . . to find out about ourselves"

Pregnancy Tests

"Interesting"

Water Pollution

"Getting the water"

Pollination

"Colorful"

Scientific Method

"It worked!"

14. What did you dislike about your least favorite lab?

Insect Behavior and Insecticides

"I don't like bugs"
"Too much microscope"
"My flies died"
"Boring and did not work"

Sewage Treatment Plant

". . . dirty and . . . smelled"
"boring" (7 students)
"I missed the lab"

Scientific Method

"Too simple"
"Too obvious"
"Don't like frogs or snails"

Animal Fertilizations and Development

"I missed the lab"

Effect of Drugs on the Frog's Heart

"Dissection" (2 students)

Intertidal Region

"Doesn't interest me"

APPENDIX II-B

SUMMARY OF STUDENT EVALUATION OF BIOLOGY 4L

FALL 1977

N = 31. All data expressed in percentages.

	Agree[a]	Neither[b]	Disagree
1. Objectives of each laboratory exercise clearly stated.	96.0	4.0	0.0
2. Materials presented related to the objectives.	100.0	0.0	0.0
3. Objectives for each laboratory exercise reached.	80.0	13.0	7.0
4. Instructions for each exercise clear and easy to follow.	80.0	17.0	3.0
5. The laboratory exercises were effective and contributed to understanding subject.	84.0	13.0	3.0
6. Amount of work required in lab: A--too little; B--appropriate; C--too much.	(A) 6.0	(B) 58.0	(C) 35.0
7. Overall evaluation of lab exercises: A--excellent; B--good; C--average; D--below average; E--poor.	(A & B) 90.0	(C) 7.0	(D & E) 3.0
8. Found labs stimulating.	70.0	30.0	0.0
9. Labs were organized.	87.0	10.0	3.0
10. Labs relevant to my interests.	77.0	13.0	10.0

[a]Strongly agree and Agree responses were included in the category Agree.

[b]Neither is used to designate neither agree nor disagree.

[c]Disagree and Strongly disagree responses were included in the category Disagree.

	Agree	Neither	Disagree
11. I would prefer to do the lab exercises during a 3-hr. lab period rather than independently.	39.0	16.0	45.0

12. Comments:

The conventional students did not respond to this question. The auto-tutorial students responded with their feelings about the course as a whole rather than responding to the laboratory only.

"Very good overall, excellent lectures, learned a lot in discussions."

"I really enjoyed the class and the different things I learned."

"Very good semester, excellent course."

"Lecture never boring."

"Lab fun."

"Great course, enjoyed every moment."

"I like the class very much."

"I had a good time."

"Overall labs were beneficial to understanding material."

"I enjoyed lab, if it were not for this type of Biology class, I don't think I would have managed."

"This Biology course was extremely stimulating."

The following minicourses are listed in order of preference shown by auto-tutorial students (Fall 1977). N = 31.

1. Intertidal Region (Field Trip)
2. Plant Community (Field Trip)
3. Pregnancy Tests and Human Heredity

4. Oakland Museum (Field Trip)
5. Effects of Drugs on the Frog's Heart
6. Water Pollution
7. Animal Fertilization and Development*
   Controlling Infections*
9. Nutrition
10. Photosynthesis and Respiration
11. Symbiosis
12. Insect Behavior and Insecticides
13. Experimenting with the Scientific Method
14. Sewage Treatment Plant (Field Trip)
15. Metrics, Microscopes and Cells
16. Ecological Adaptations of Tracheophytes

13. What did you like best about your favorite lab?

"In general labs interesting and enjoyable."
"Field trips . . . to understand better."
"Didn't dislike any." (2 students)

Intertidal Field Trip

"Easy to understand and follow through."
"Nature, diversity; interesting; more fun than lab."
"Being outdoors; interesting--good opportunity to do something otherwise might not have known about."
"Creatures interesting; natural; looking for things."

San Pedro Creek

"Hiking; walking, learning about eucalyptus tree; investigating."

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*Two minicourses tied for number seven.

Pregnancy Tests

"Fun."

Oakland Museum

"Interesting; I know about it."

Effect of Drugs on the Frog's Heart

"Working with and observing living system."
"Seeing how heart works."
"Dissection."

Water Pollution

"Pertinent."

Animal Fertilization and Development

"Interesting."

Controlling Infections

"Antibiotics."

Insect Behavior and Insecticides

"Ecologically interesting; CAI."

Experimenting with the Scientific Method

"Observing; using snails."

Sewage Treatment Plant (Field Trip)

"Well done."

14. What did you dislike most about your least favorite lab?

Metrics, Microscopes and Cells

"Metrics not covered well enough."
"Important but boring."
"Doing metrics."
"Looking at cells."
"Hate measuring."

Sewage Treatment Plant

"Smell" (4 students).
"Irrelevant to my interests."

Experimenting with the Scientific Method

"To much to do and not enough time."
"Snail wouldn't do what it was supposed to."
"Heavy load for first lab."
"Slow, not too exciting."
"Nothing to use, not interesting."

Photosynthesis and Respiration

"Too repetitious, dragged on too long

Nutrition

"Too many little things to do."

Controlling Infections

"Boring."

Animal Fertilization and Development

"Too many variations on outcome."
"Too long for results."

Effect of Drugs on the Frog's Heart

"Killing" (3 students).

Pregnancy Tests

"Boring and dragged on."
"Injecting the frog."
"Boring and unorganized."

APPENDIX III

MINICOURSES USED IN "MAN IN A BIOLOGICAL WORLD" LABORATORY DURING THE FALL 1977 SEMESTER

1. Experimenting with the Scientific Method
2. Metrics, Microscopes and Cells[1]
3. Photosynthesis and Respiration[2]
4. Ecological Adaptations of Tracheophytes[3]
5. Plant Community Field Trip[1]
6. Water Pollution[4]
7. Sewage Treatment Plant Field Trip
8. Insect Behavior and Insecticides[4]
9. Intertidal Region Field Trip
10. Symbiosis
11. Nutrition[5]
12. Pregnancy Tests and Human Heredity[6]
13. Animal Fertilization and Development
14. Effects of Drugs on the Frog's Heart
15. Controlling Infections[4]
16. Oakland Museum Field Trip[1]

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[1]These exercises were not used during previous semester.

[2]Formerly Primary Productivity. Minicourse expanded to include experiments dealing with respiration.

[3]Formerly Pollination. Minicourse expanded to include general information on plants and have more "hands-on."

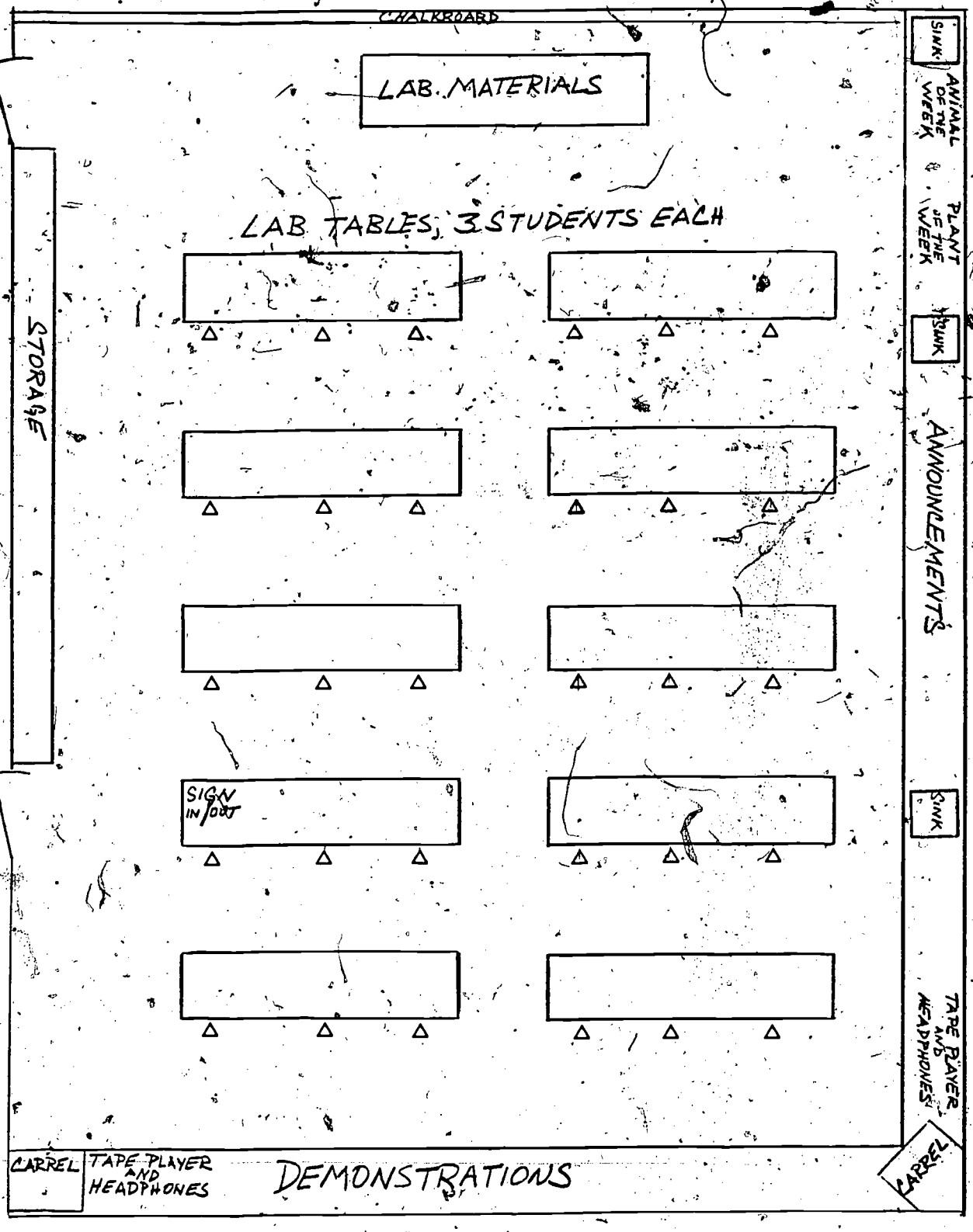
[4]Computer simulation was added for the Fall 1977 semester.

[5]Formerly Harvesting the Sea. Minicourse was expanded to include more general information on nutrition.

[6]Formerly done as two separate laboratory exercises.

APPENDIX IV

DIAGRAM OF LABORATORY USED FOR "MAN IN A BIOLOGICAL WORLD" FALL 1977


CHALKBOARD
SINK
ANIMAL OF THE WEEK
PLANT OF THE WEEK
SINK
ANNOUNCEMENTS
SINK
TAPE PLAYER AND HEADPHONES
CARREL 2
LAB. MATERIALS
STORAGE
LAB TABLES, 3 STUDENTS EACH
SIGN IN/OUT
CARREL
TAPE PLAYER AND HEADPHONES
DEMONSTRATIONS

APPENDIX V

STUDENTS' FINAL GRADES SPRING 1975 THROUGH FALL 1977

Table 6. Final grades of students in "Man in a Biological World" Spring 1975 through Fall 1977.

Semester	Number of Students	Number of Students Receiving					Percent W
		A	B	C	D	F	
Spring 1975	72	15	26	25	15	1	12.8
Fall 1975	53	9	13	25	6	0	26.6
Spring 1976	25	5	8	10	2	0	32.4
Fall 1976	25	2	4	15	4	0	32.4
Spring 1977	28	9	6	7	4	1	32.5
Fall 1977	43	10	9	14	6	2	5.0